UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
ENVIRONMENTAL
CLEANUP

January 16, 2018

MEMORANDUM

SUBJECT: Midnite Mine Superfund Site Record of Decision (ROD) – Clarifying Basis for Cleanup Level for Radium-226 in Surface Materials and Minor Revisions to ROD and RI

FROM: Karen Keeley, RPM and Kelly Cole, ORC

TO: Midnite Mine Site File

The purpose of this Technical Memorandum is to provide clarifying information on the technical basis for the Radium-226 cleanup level for "Surface Materials" in the Record of Decision (ROD) for Midnite Mine (EPA 2006); provide revisions to Table 5-3 of the ROD and Table 4-12 of the RI; and, to obtain concurrence for the two attachments to this memorandum:

Attachment 1: Summary of Information related to Background Concentrations of Contaminants of Concern in Surface Material and Calculation of the Cleanup Level for Radium-226 in the Record of Decision (2006), Midnite Mine Superfund Site, Spokane Indian Reservation, WA", dated December 19, 2017.

Attachment 2: Corrected tables for the ROD and RI, which are part of the Administrative Record.

These revisions do not affect the final remedy. As such, they do not require an Explanation of Significant Differences or other amendment.

This correction memorandum, which includes two attachments, will be added to the Site File.

Attachment 1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
ENVIRONMENTAL
CLEANUP

December 19, 2017

MEMORANDUM

SUBJECT: Summary of Information related to Background Concentrations of Contaminants of Concern in Surface Material and Calculation of the Cleanup Level for Radium-226 in the Record of Decision (2006), Midnite Mine Superfund Site, Spokane Indian Reservation, WA

FROM: Karen Keeley, RPM

TO: Site File – Midnite Mine Superfund Site

The purpose of this memorandum is to document the dataset, analytical method, and statistical approach used as the basis for the cleanup level for radium-226 (Ra-226) established in the Record of Decision (ROD; EPA 2006) for "surface material"[1] at the Midnite Mine Superfund Site (Site). This information is being clarified because it was not clearly presented, or was inconsistently presented, in the Remedial Investigation/Feasibility Study (RI/FS) and ROD. This memorandum will be filed and linked with the RI/FS and ROD, and will be posted on EPA's Midnite Mine website.

Background Information

The Record of Decision (ROD) (EPA 2006; Table 8-3) for Midnite Mine identifies a cleanup level of 4.7 pCi/g for Ra-226 in surface material. The cleanup level is defined by the 95% Upper Tolerance Limit (UTL) of background concentrations of Ra-226 in surface material from a nearby area unimpacted by mining site releases (ROD; Table 5-4). As described in the ROD, the cleanup level is defined by background levels rather than on concentrations based on risk because the risk-based concentrations determined for Ra-226 at the Site, and any applicable regulatory standards, are below background levels.[2,3]

Summary of Background Surface Material Sample Collection in 2000 and Analysis for Ra-226

During the Remedial Investigation/Feasibility Study (RI/FS) at the Site, background data on Contaminants of Concern (COCs), including Ra-226, were obtained from two areas north of the mine site in September and October 2000. These two areas, designated as Background Area A and Background Area B[4], are shown on a geologic map in Figure 1.

The collection of surface material samples is described in Sections 3.3.1.2 and 4.6.1 of the *Midnite Mine Remedial Investigation Report* (URS, September 2005). Twenty surface samples

from a very thin surface layer [0 to 2 in (0 - 5 cm)] were collected from each area for a total of 40 surface samples. Also, 8 subsurface samples (co-located with surface samples) were collected from 2 to 8 in (5-20 cm) from each area for a total of 16 subsurface samples. The locations of these samples are shown on Figure 2.

While the surface and subsurface samples were analyzed for a number of constituents, only Ra-226 will be discussed in this memorandum. The reason for focusing on Ra-226 is that recent cleanup work in the Northern Construction Support Zone at the site found that weathered surface material at the bottom of the excavations, believed to be naturally-occurring and unimpacted by mining activities, was found to contain Ra-226 concentrations in excess of the cleanup level.[5]

The background surface material samples that were collected in 2000 were analyzed in late 2000 and early 2001 for Ra-226 in the U.S. EPA National Air and Radiation Environmental Laboratory (NAREL[6]) using gamma spectrometry following NAREL Method GAM-01. Use of NAREL Method GAM-01 was specified in Section A 7 2 2 6 (page A-32 of A-36) of the *Quality Assurance Project Plan for the Midnite Mine Phase 2A/1B RI/FS, Revision 1*, URS, November 30, 2000[7]. Section A 7 2 2 6 language is provided below:

> "[Pursuant to the earlier August 1999 Phase 1A QAPP] Analytical data for Ra226 for Phase 1A Round 1 sediment analyses are being obtained by two analytical methods: the de-emanation method specified in the Phase 1A QAPP and also through gamma spectroscopy by NAREL Method GAM-01."
>
> "Once all Ra226 data (by both methods) and U235 data are obtained from the Phase 1A Round 1 analyses, a site-specific evaluation will be made as to whether correction for U235 interference can be performed to provide gamma spectroscopy Ra226 data with accuracy adequate for risk assessment purposes. If an adequate correction method is developed, then it will be applied to gamma spectroscopy data obtained during analysis of surface material and sediment during Phase 2A [which includes background sampling] and 1B sampling. If evaluation of these data for a given medium indicates that the Ra226 activities obtained from the gamma spectroscopy data are of adequate accuracy and sensitivity for risk assessment purposes, then no additional analyses of the Phase 2A and 1B samples by the de-emanation method will be conducted." [emphasis added]

Since the Ra-226 gamma spectroscopy data were determined to be adequate in the above-referenced evaluation, the background surface material samples were analyzed using only the method NAREL GAM-01 (and not by radon emanation). Further clarification that surface material samples, including background samples, were analyzed for Ra-226 using NAREL GAM-01 is provided in EPA's December 19, 2000 transmittal memorandum[8] approving the Phase 2A/1B QAPP. EPA's memorandum states:

> "Analytical changes include the use of gamma spectroscopy rather than radon

de-emanation to obtain Ra226 for soil [surface material] samples. … NAREL estimates that it will conclude its analyses in April 2001." [emphasis added]

The URS (May 23, 2001; p. 2) report "*Preliminary Evaluation of Laboratory Data from Riparian Sediment and Surface Material Samples and Recommendations for Further Data Collection*" states:

- "After sample ingrowth, Ra-226 activity is equal to Bi-214 activity which equals Pb-214 activity. Therefore, Bi-214 activity values from the gamma spectroscopy analysis were used for the statistical comparison in lieu of Ra-226 activities."

- "The gamma spectroscopy Bi-214 results (after ingrowth of radon) reported by NAREL were used to represent Ra-226."

A copy of the most current version of the NAREL gamma spectrometry method was obtained from NAREL in August 2017 (see *"NAREL Standard Operating Procedure for Gamma-Ray Spectrometry AM/SOP-3, Revision 7*" in Attachment A). As shown in the Document Control Numbers on page i of NAREL's method, Revision 0 of this NAREL gamma spectrometry method is identified as "Gam-01". This clearly documents that "NAREL Gam-01" has consistently been a gamma spectrometry method[9] (and not a radon emanation method) and that this was the method used to analyze the background surface material samples at the Site. On November 28, 2017, EPA confirmed with Tonya Hudson of NAREL that NAREL's database shows that the background samples were analyzed using NAREL GAM-01.

While not directly relevant to this memorandum, various radiation methods for Ra-226 analysis have historically been used for media at Midnite Mine and while the numerical method is listed in the QAPPs, the actual methodology may not be described. For informational purposes, these methods are summarized in Attachment B.

Analytical Results for Ra-226 in Background Surface and Subsurface Samples of Surface Material

Results of background surface and subsurface Ra-226 concentrations are provided in Table 1 and shown in Figure 2. A summary of the analytical results for background surface material samples were excerpted from Appendix D of the RI (URS 2005) and are provided in Attachment C. An Excel Spreadsheet of all analytical results for background, in its original form including all analytes, is provided in Attachment D. Analytical results in Attachments C and D incorrectly label Ra-226 results as "Radium 226, Calculated Totals" (see explanation in cover pages to Attachments C and D). Results should have been labelled "Radium 226."

Summary of Approach Used to Calculate Cleanup Level for Ra-226 in Surface Material

The ROD cleanup level for Ra-226 was calculated using background concentrations of Ra-226 from 16 subsurface (5-20 cm) samples collected from Midnite Mine Background Areas A and B consistent with *Quality Assurance Project Plan for the Midnite Mine Phase 2A/1B RI/FS, Revision*

1 (URS, November 30, 2000). Ra-226 concentrations from the 16 subsurface samples are shown in Table 1 (Column 2). Background surface (0-5 cm) sample data for Ra-226 were not used.[10]

To confirm the calculation of the ROD cleanup level of 4.7 pCi/g Ra-226, results from the 16 subsurface samples were pooled for statistical analysis to determine the 95% Confidence Upper Tolerance Limit (UTL) with 95% Coverage (generally referred to as 95%/95% UTL values). The output from ProUCL is summarized in Table 2. ProUCL results are provided in Attachment E. EPA requested technical statistical support from an EPA oversight contractor to perform this statistical analysis to verify the 95%/95% UTL for Ra-226 because this information could not be found in documents in the Midnite Mine Site File and the data set used to calculate the cleanup level was not articulated in the RI/FS or the ROD.

Other Minor Clarifications and Corrections to the 2000 QAPP for Phase 2A/1B and the 2006 ROD

1. In Table 4-12 of the RI, the analyte for Ra-226 data is incorrectly shown as "Ra-226, Calculated." See prior discussion – the values are total Ra-226. Further, the column showing "BL" for subsurface (SB) data shows 4.7 pCi/g Ra-226 as the "Background Limit (99% upper tolerance limit)." This is incorrect. The value of 4.7 pCi/g Ra-226 is actually the 95% UTL, as reported in Table 4-11 of the RI, and documented in this memorandum.

2. Table 5-3 of the ROD, the final column shows the "HHRA 95% UTL" for various COCs. The HHRA 95% UTL values are not relevant to the discussion of background limits that is presented in Section 5.3.1 of the ROD and tabulated in Table 5-3. The "HHRA 95% UTL" was not used to establish cleanup levels. According to the HHRA (URS 2005), the only relevance of the values identified as "HHRA 95% UTL" is as follows:

   > "Background data were also used in the selection of COPCs for the risk assessment. The background data were used to calculate 95 percent upper tolerance limits (UTLs) for each contaminant, in accordance with EPA guidance (EPA 2002b). The use of the 95 percent UTL as a screening value was intended to reduce the likelihood of falsely concluding that site levels are above background levels (EPA 2002b)."

3. In Table 5-3 of the ROD (p. 2-26), for background surface material samples, the first column identifies radium using the term "Ra-226, calculated" while the correct term should be "Ra-226" given that the concentrations are analytical results from a gamma spectrometry method (NAREL GAM-01) and they are not "calculated." See Attachments C and D for further details. Value of 4.7 pCi/g is 95% UTL.

4. In the November 2000 QAPP for Phase 2A/1B, several tables [e.g., 1) Table B.4.4-2f-P2 RADIONUCLIDES - QC ACCEPTANCE CRITERIA, incorrectly indicates that the analytical method for Ra-226 in "Sediment/Surface Material" is NAREL Ra-01 and Ra-04; and, 2) Table B.4.3-1-P2, PHASE 2 QC SAMPLE SUMMARY AND SAMPLE CONTAINERS AND PRESERVATIVES]

incorrectly indicate that NAREL Method Ra-01 and Ra-04 (radon de-emanation methods) would be used for Ra-226. It is clear from other sections of the QAPP (see earlier text cited from the QAPP), footnotes from Table A 8 in appendix A of the 2000 QAPP, and the actual data results, that NAREL GAM-01 (a gamma spectrometry method) was used for Ra-226 in background surface material samples.

In response to one reviewer's comment, it is noted that it appears that the cleanup level for uranium in surface material was defined by the 95% UTL of pooled subsurface data, while the cleanup level for Pb-210 in surface material was defined by the 95% UTL of pooled surface data.

Conclusion

This memorandum documents that a gamma spectrometry method was used to calculate the Ra-226 concentrations in surface material samples from Background Areas A and B. In the raw data set, the values used to calculate the background concentrations are listed as "Radium-226, Calculated Totals", when in fact these are simply Ra-226 total concentrations and they were not calculated. The ROD cleanup level for Ra-226 was defined by the 95% UTL using background concentrations of Ra-226 from 16 subsurface (5-20 cm) samples. Surface (0-5 cm) samples were not used.

This memorandum was reviewed by the Newmont Mining Company and EPA's Oversight contractor, CH2M Hill. The memorandum will be filed and linked with the RI/FS and ROD, and will be posted on EPA's Midnite Mine website.

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[1] As defined in the ROD (EPA 2006), surface material includes soil, ore, proto-ore, waste rock, overburden, and materials used in haul road construction. Sediments include sediments in pits, ponds, creeks and drainages.

[2] EPA guidance and policy do not recommend that cleanup levels be established at levels below background, even if the background level exceeds a regulatory standard or risk-based concentration (EPA 2002; OSWER 9285.7-41). Where a regulatory standard or risk-based concentration is greater than the background level, the standard or risk-based concentration is used as the cleanup level (See Section 104[a][3][A] of CERCLA and Section 8.3 of the 2006 Midnite Mine ROD). As described in Section 8.3.3 of the 2006 ROD, "The cleanup to background concentrations in circumstances of elevated background concentrations is consistent with Section 104(a)(3)(A) of CERCLA. It is also specifically authorized by the Spokane Tribe Hazardous Substances Control Act (HSCA) if natural conditions exceed a specific standard." As stated in the ROD (Section 8.3), "For the Midnite Mine Site, the cleanup levels are generally based on background levels rather than on concentrations based on risks, because most of the regulatory standards and risk-based concentrations for the Site are below background levels."

[3] As described in the ROD Responsiveness Summary (Section 1), "background" approximates pre-mining conditions, but is based on current conditions in nearby areas unimpacted (not influenced) by mining

site releases. Cleanup of naturally-occurring surface material at the site that is not impacted by mine operations is not required by the Record of Decision (ROD). The Cleanup Levels are for all surface material at the Site and are not specific to the multiple types of different geological material that are present at the mine.

[4] Originally, the terms "mineralized" and "non-mineralized" were used to describe Background Areas A and B, respectively, but these terms were later modified and were no longer used as explained in Appendix B of the RI (URS 2005). In Appendix B, the explanation is provided in Section 7.3.1 of the "*Technical Memorandum for Suitability of Background Sampling Used to Establish Site Impacts*" (URS 2003): "The two background areas sampled for surface materials were located east and northeast of the site. Sampling of these areas is summarized in Sections 3.1 and 3.3. Initially, the two areas had been referred to as "mineralized" and "non-mineralized". This terminology was intended to indicate that the northeastern area (Spokane Mountain) was underlain by an ore deposit. It was not intended to indicate the presence of ore mineralization at or near the land surface. Because these names could lead to misunderstandings they are not used in this memorandum. The surface material areas are called Background Area A (located northeast of the site and underlain by quartz monzonite and the Togo Formation) and Background Area B (located east of the site and underlain by quartz monzonite)."

[5] See "Work Plan for Evaluation of Naturally Occurring Background Concentrations of Contaminants of Concern in Quartz Monzonite and Togo Schist Surface Materials at the Midnite Mine" (WME October 12, 2017), including "Recent excavations in the Northern Construction Support Zone (NCSZ) identified extensive unweathered QM [quartz monzonite] bedrock material overlain by an average of 2 to 4 ft of weathered QM material and a topping of 1 to 1.5 ft of silty loam/topsoil material. The unweathered QM (which passed the bucket refusal test) is naturally-occurring material, and overlying weathered QM bedrock is also believed to be naturally occurring. The weathered QM had concentrations of radium-226 (Ra-226) that were in excess of the Cleanup Levels for Surface Material. Since many of these areas had been excavated to depths of several feet below any area of visual impacted and into unaltered natural soil formations and into weathered bedrock, it is believed that these areas are not impacted by mine waste."

[6] The laboratory is now named the U.S. EPA National Analytical Radiation Environmental Laboratory (NAREL), Montgomery, Alabama.

[7] Subsequent to the background sampling field effort completed in September and October 2000 and the approval of the final November 30, 2000 QAPP for Phase 2A/1B, EPA approved an October 10, 2001 Addendum No. 1 to the QAPP for Phase 2B activities. Phase 2B activities did not include the collection of background samples, as they had previously been collected and analyzed. The Phase 2B activities included locations and analyses for "verification samples [that] will be collected from PIA [Potentially Impacted Area] surface material [samples labelled SMEHR, SMDWNE, SMWHR] and riparian sediment locations appearing to be affected relative to background based on comparison against a preliminary indicator parameter list." Text further states that the verification samples were collected as part of a "resample strategy used in conjunction with the recommended population size for the background data set is among the sampling strategies strongly recommended by EPA to achieve a reasonable balance between false positive and false negative errors (EPA 1992)." None of these Phase 2B data were used for the calculation of cleanup levels.

[8] EPA's December 19, 2000 transmittal memo approving the Phase 2A/1B QAPP was written after the background samples were collected.

[9] In the spectrum graph generated by gamma spectroscopy after 21 days of ingrowth, the peak that is measured for Ra-226 also includes U-235 concentrations. Instead of measuring that combined peak (which is an overestimate of Ra-226), the gamma spec method for Ra-226 allows for a different peak (Bi-214) on the graph to be measured – in a sample, this Bi-214 peak will always have the same concentration as Ra-226 because both radionuclides will have reached secular equilibrium at 21 days.

As described in the Midnite Mine RAWP, Appendix S: "Gamma spectroscopy with either NaI or HPGe detectors relies on short-lived gamma-emitting decay products of Rn-222 (namely Bi-214 and/or Pb-214). For this reason, soil analysis by gamma spectroscopy requires that soil samples be sealed in special counting canisters for at least 21 days to allow Rn-222 and its decay products to build into a state of secular equilibrium with their long-lived Ra-226 parent."

[10] While a thorough review of site-specific documents (e.g., the RI/FS, URS Technical Memoranda on Background, and the ROD) was performed, no language has been found clarifying why surface samples of surface material from Background Areas A and B were not included in the background calculations to establish the Ra-226 cleanup level. There is nothing in any of the background reports that suggest only the subsurface data should be used. In fact, Section 7.3.3 Appendix B-2 ("*Technical Memorandum for Suitability of Background Sampling Used to Establish Site Impacts*") (URS 2005) states: "Pooling the data from the two areas is reasonable and provides sampling from a sufficient range of rock types to evaluate surface material background concentrations." and "Overall, the similarity in the background values between Background Areas A and B mean that these data can be pooled for the purposes of the RI/FS." Further, Section 4.6.1.5 (p. 4-49) of the RI indicates that the background areas were not impacted by windblown dust.

Table 1. Midnite Mine Surface and Subsurface Surface Material (Soil) Ra-226 Background Data

Location ID (n=40)	Surface (0-5 cm) Ra-226 (pCi/g)	Location ID (n=16)	Subsurface (5-20cm) Ra-226 (pCi/g)
SMBKMIN-01	1.57		
SMBKMIN-02	1.78	SSBKMIN-02	1.89
SMBKMIN-03	1.89		
SMBKMIN-04	2.16	SSBKMIN-04	2.20
SMBKMIN-05	1.97	SSBKMIN-05	1.97
SMBKMIN-06	1.69		
SMBKMIN-07	1.87		
SMBKMIN-08	1.65		
SMBKMIN-09	1.85		
SMBKMIN-10	2.21	SSBKMIN-10	2.11
SMBKMIN-11	8.24		
SMBKMIN-12	2.25		
SMBKMIN-13	1.93	SSBKMIN-13	1.66
SMBKMIN-14	8.92		
SMBKMIN-15	1.67	SSBKMIN-15	1.56
SMBKMIN-16	2.37		
SMBKMIN-17	3.23	SSBKMIN-17	3.00
SMBKMIN-18	2.40		
SMBKMIN-19	3.84	SSBKMIN-19	3.87
SMBKMIN-20	1.80		
SMBKNON-01	2.88		
SMBKNON-02	1.49	SSBKNON-02	1.40
SMBKNON-03	1.89		
SMBKNON-04	2.52	SSBKNON-04	2.30
SMBKNON-05	2.27		
SMBKNON-06	2.50		
SMBKNON-07	3.37	SSBKNON-07	3.18
SMBKNON-08	3.03		
SMBKNON-09	2.38	SSBKNON-09	2.58
SMBKNON-10	2.35		
SMBKNON-11	2.97		
SMBKNON-12	1.88	SSBKNON-12	2.16
SMBKNON-13	2.20		
SMBKNON-14	3.00		
SMBKNON-15	3.16	SSBKNON-15	3.07
SMBKNON-16	1.69		
SMBKNON-17	1.33		
SMBKNON-18	1.51	SSBKNON-18	1.61
SMBKNON-19	2.97	SSBKNON-19	2.89
SMBKNON-20	2.11		

Notes:

The analytical method used for these data was a gamma spectrometry method (NAREL GAM-01).

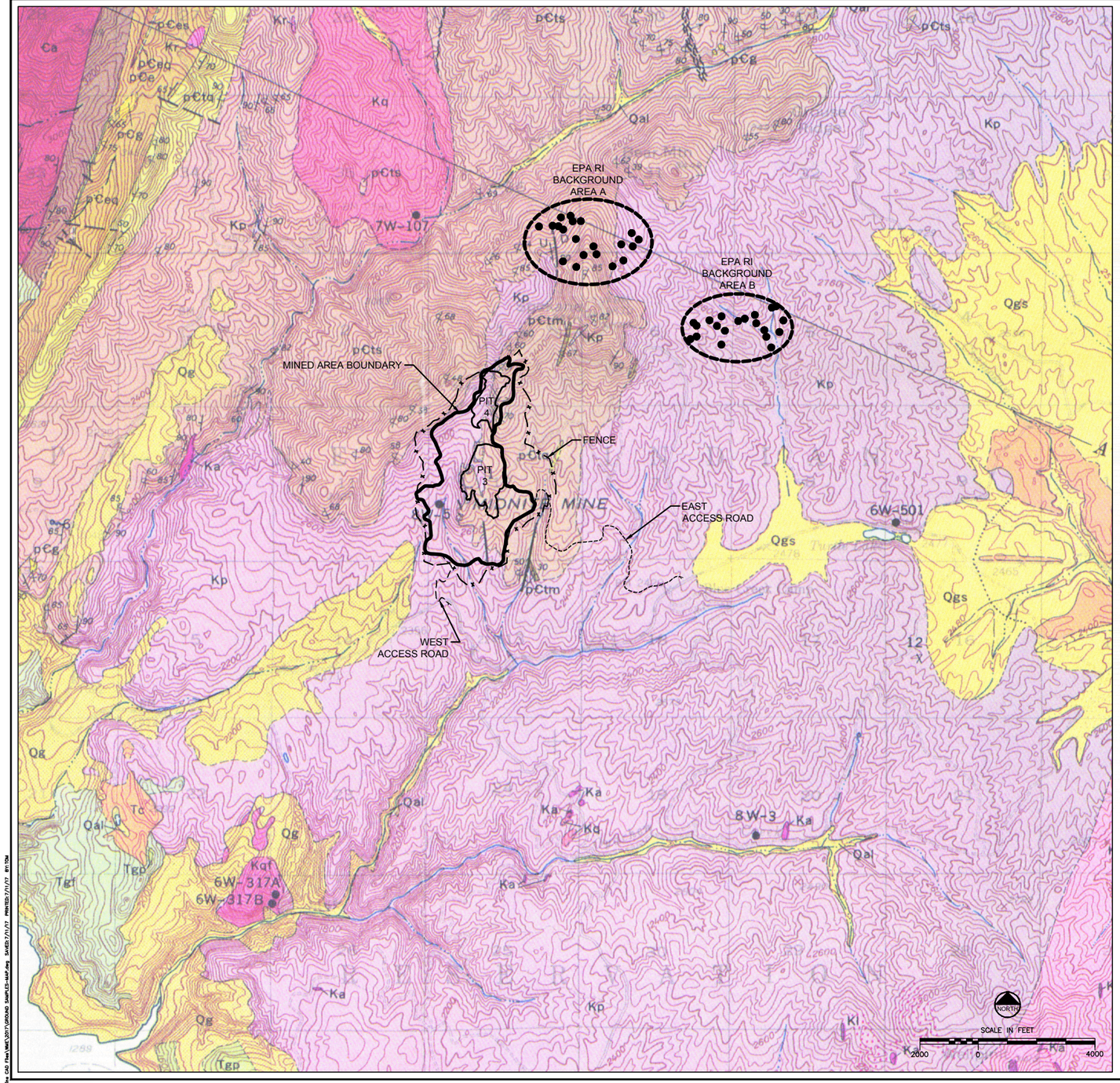
Data are from Appendix D of the Midnite Mine Remedial Investigation Report (URS September 2005).

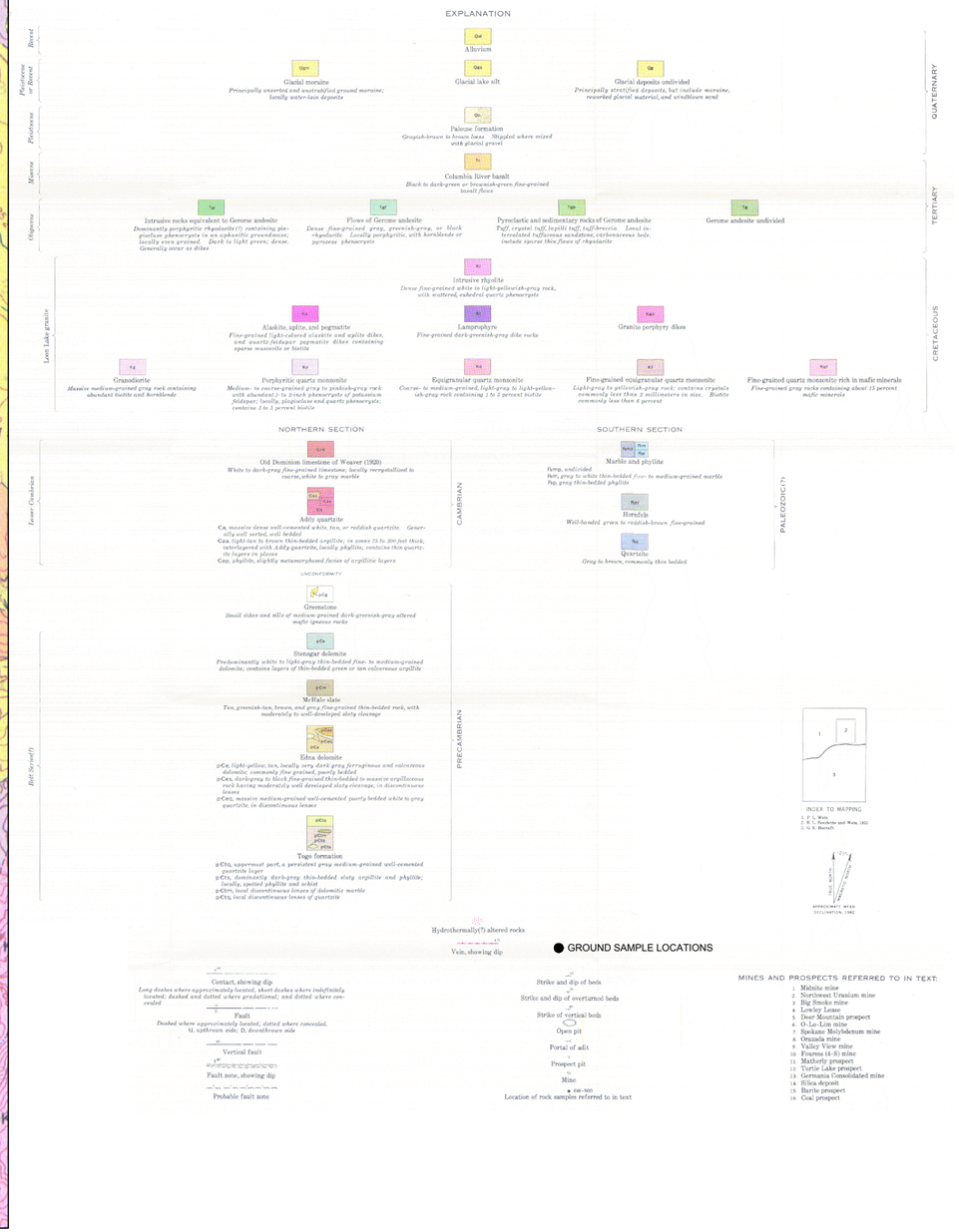
See Attachments C and D for a discussion of analytical results and reporting.

Table 2. Results of 2017 Statistical Analysis of Ra-226 Background Subsurface Data for Surface Material at Midnite Mine.

Distribution Type	Goodness of Fit (p-value)	95% UTL Ra-226 (pCi/g)
Lognormal	**0.837**	**4.72**

Data collected in 2000 from Background Areas A (n=8) and B (n=8).
Note: For the statistical evaluation, EPA's oversight contractor (CH2M, Aditya Tyagi) determined the distribution that best characterized the data. In this case, three distributions, namely the Normal, Lognormal, and the Gamma distributions all fit the data, but the Lognormal distribution fits the best. Thus, the lognormal distribution was selected to determine the 95%UTL value.





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REVISIONS No.	DESCRIPTION	BY	CHKD.	APPROVED		DATE

REFERENCES DWG No.	DRAWING TITLE

DESIGNERS ENGINEERING RECORD	BY	DATE

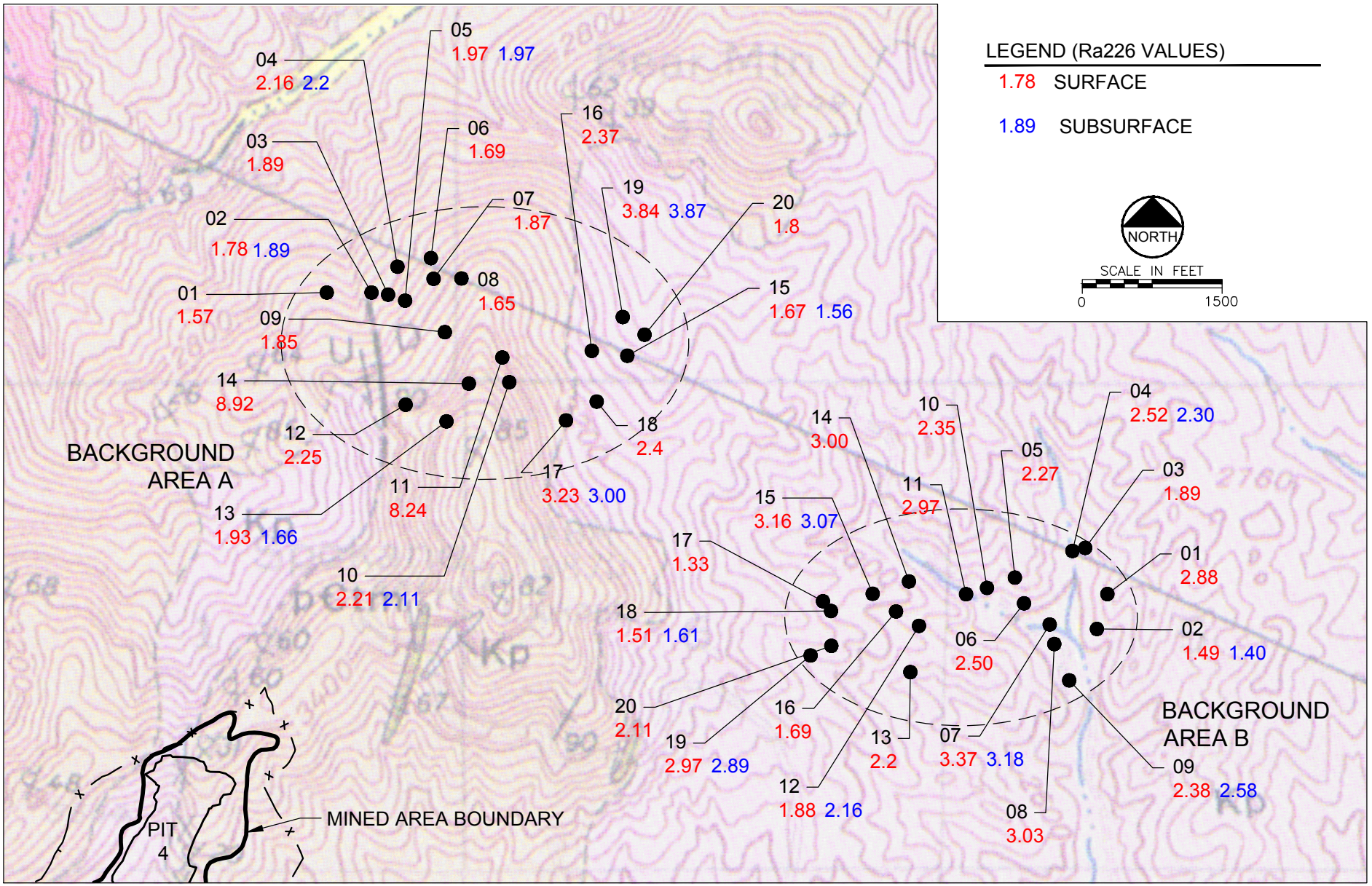
PREPARED BY
WORTHINGTON MILLER ENVIRONMENTAL, LLC.

PREPARED FOR

TITLE
FIGURE 1
GEOLOGIC MAP AND BACKGROUND AREAS AT MIDNITE MINE AND SURROUNDING AREA

PROJECT: MIDNITE	DATE: JULY 2017	DRAWING	REVISION
SCALE: AS SHOWN	FILE: GROUND SAMPLES-MAP		△

Z:\Project Files\Midnite\AutoCAD Files\Midnite Mine CAD Files\WME\2017\GROUND SAMPLES-01.dwg SAVED: 7/11/17 PRINTED: 7/11/17 BY: TOM



WORTHINGTON MILLER ENVIRONMENTAL, LLC.	FIGURE 2. BACKGROUND SAMPLE LOCATIONS AND RESULTS FOR RA-226 (only Subsurface Samples were used to calculate Cleanup Levels)	Date: JULY 2017 Project: MIDNITE File: BACKGROUND SAMPLES-01

Attachment A

NAREL Standard Operating Procedure for Gamma-Ray Spectrometry AM/SOP-3

Keeley, Karen

From: Hudson, Tonya
Sent: Wednesday, August 30, 2017 6:50 AM
To: Keeley, Karen
Cc: White, Cindy; Clark, Mike S.
Subject: FW: NAREL Gamma Method
Attachments: Doc-10-gamma spect-Rev7-2017-04-12-lan.pdf

Hi Karen,

As requested in the email below, attached is the current version of the NAREL gamma method, AM/SOP-3. Please pay special attention to the paragraph at the bottom of the title page.

Let me know if you have problems with the file or need further assistance,
Tonya

From: Keeley, Karen
Sent: Tuesday, August 29, 2017 5:10 PM
To: Clark, Mike S. <Clark.Michael@epa.gov>; White, Cindy <White.Cindy@epa.gov>
Cc: McCroan, Keith <mccroan.keith@epa.gov>; Griggs, John <Griggs.John@epa.gov>
Subject: RE: NAREL Gamma Method

Thanks! Our records show that in late 2000/early 2001 NAREL used method NAREL GAM-01 for analysis of "Surface Materials' (ie soil) for Ra-226 at the Midnite Mine Superfund Site. Based on language in the QAPP and results it was a gamma spec method.

Karen Keeley | **Superfund Remedial Project Manager**
U.S. Environmental Protection Agency | Region 10
Office of Environmental Cleanup
1200 6th Avenue, Suite 900, ECL-122 | Seattle, WA 98101
p: 206.553.2141

From: Clark, Mike S.
Sent: Tuesday, August 29, 2017 3:07 PM
To: White, Cindy <White.Cindy@epa.gov>
Cc: McCroan, Keith <mccroan.keith@epa.gov>; Keeley, Karen <Keeley.Karen@epa.gov>; Griggs, John <Griggs.John@epa.gov>
Subject: NAREL Gamma Method

Cindy,
Karen Keeley (Reg 10) has asked for a copy of a NAREL Gamma method.

Please contact Karen and see how we can help her.

Karen's phone number is - 206-553-2141, email is keeley.karen@epa.gov.

Thanks
Mike

Michael Clark
Deputy Director
U.S. EPA
National Analytical Radiation Environmental Laboratory (NAREL)
540 South Morris Avenue
Montgomery, AL 36115-2600
email: clark.michael@epa.gov
office: (334)270-3404
fax: (334)270-3454

NAREL Standard Operating Procedure
for Gamma-Ray Spectrometry

AM/SOP-3

Revision 7

Effective Date April 12, 2017

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National Analytical Radiation Environmental Laboratory
Office of Radiation and Indoor Air
540 S. Morris Avenue
Montgomery, Alabama 36115
1-334-270-3400

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DOCUMENT APPROVAL FORM

Title:	NAREL Standard Operating Procedure for Gamma-Ray Spectrometry
Index number:	10
Document control number:	AM/SOP-3
Revision number:	7
Effective date:	2017-04-12
Software version:	Word 2016
Responsible unit:	CERLS
Coordinator:	R. Michelle Owens

APPROVALS:

Cynthia White — 4-11-17
Cynthia White
Director, CERLS
Date

Velinda Herbert — 4/11/17
Velinda Herbert
Quality Assurance Manager, NAREL
Date

John Griggs — 4/11/17
John Griggs, PhD
Director, NAREL
Date

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AM/SOP-3

Revision History

Rev.	DCN	Coordinator	Date
0	Gam-01	David P. Saunders	2001-05-23
1	AM/SOP-3	Robert Lowry	2008-06-11
2	AM/SOP-3	Robert Lowry	2010-05-05
3	AM/SOP-3	Robert Lowry	2010-12-14
4	AM/SOP-3	R. Michelle Owens	2013-09-03
5	AM/SOP-3	R. Michelle Owens	2014-10-07
6	AM/SOP-3	R. Michelle Owens	2016-04-26
7	AM/SOP-3	R. Michelle Owens	2017-04-12

Changes Between Revisions 6 and 7	
Section	**Description of Changes**
5.1.1.1	Deleted reference to ANSI/IEEE STD 325-1986.
7.5	Changed “When possible” to “If needed.”
8.2	Combined information from 8.3 into 8.2 and added note to not preserve if analyzing for radioiodine.
8.3	Section deleted and information added to 8.2
9.2.1	Updated Section 9.2.1 to clarify adjustment of electronics for energy calibration.
9.3.1.4	Added reference to NC/SOP-10 Appendix 18.1.
11.2	Updated location of the records.
12.2.2.2	Updated to reflect current practices.
12.2.2.3	Added cross-reference to new Appendix 19.1.
13.3	Added a reference to correcting sample spectra for coincidence summing.
14.2	Changed Counting Room Manager to Counting Room Team Leader.
14.3	Added possible data entry errors that need to be checked.
14.4	Updated review of instrument efficiency checks to reflect current procedure.
14.9	Added how reviewer should confirm presence of unusual nuclides.
14.10	Section covered milk samples. Section has been deleted.
14.11.1	Section added to clarify adjustment of peak match width.
14.12	Updated standard references.
14.13	Removed reference to Cs137 milk samples.
14.14	Updated results that are qualified as estimated.
18.0	Removed references that are not needed.
19.1	Added Appendix 19.1, adapted from earlier “CERLS Gamma LCS Standard Recertification Policy.”

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1.0 PURPOSE

1.1 This procedure describes the method used at NAREL for quantifying the absolute activity, volumic activity, or massic activity of radionuclides in various sample matrices by gamma-ray spectrometry.

2.0 SCOPE AND APPLICATION

2.1 This is a general procedure for radioassay of samples by gamma-ray spectrometry to characterize the gamma-emitting radionuclides present without separating them from the sample matrix. This procedure can be used for sample matrices including water, soil, vegetation, tissue, and others.

2.2 The detection and quantification capabilities of this method are functions of matrix, aliquot size, matrix interferences, counting geometry, detector efficiency, background, counting time, gamma photon energies of the nuclide(s) of interest and branching fractions of the photons.

2.3 Liquid samples are acidified and soil samples are ground and sieved to ensure the homogeneity of the samples. Samples are then placed in a standard counting geometry for which the system is calibrated. Based on available sample size, the counting geometry that provides the highest counting efficiency is chosen for gamma spectral analysis. Samples are then counted and analyzed using commercially available software for instrument control and data reduction.

2.4 *Interferences*

2.4.1 During sample counting, other gamma-ray-emitting sources must be shielded or removed from the proximity of the detector.

2.4.2 Gamma-ray events from different nuclides in the sample matrix whose energies the detector cannot resolve may result in higher than expected reported activities for either or both of the nuclides.

3.0 DEFINITIONS

3.1 **branching fraction** – the ratio of the number of parent atoms decaying by a particular mode to the total number of decaying parent atoms. Branching fractions are often listed as percentages.

3.2 **dead time** – the minimum time separation between gamma events required for the detector to record both as separate pulses. New events that occur during the dead time interval are not detected. The total dead time for a gamma measurement is the total time the detector spends processing events, during which it cannot detect new events.

3.3 **dewar** – container for storing liquefied gases, with an evacuated double wall for insulation.

3.4 **energy resolution** – a measure of a detector's ability to distinguish gamma photon energies. The standard measure of resolution is the FWHM of the 1332.5 keV photopeak of ^{60}Co.

3.5 **FWHM** – acronym for full width at half maximum – the width of a gamma photopeak at half its maximum height above the spectral continuum. A measure of a detector's energy resolution.

3.6 **keV** – a unit of energy equal to the energy acquired by 1 electron accelerating across a potential of 1000 V in a vacuum; it is equal to 1.602 176 487(40) × 10^{-16} J.

3.7 **live time** – the difference between the real time of the data acquisition and the total dead time.

3.8 **LN2** – liquid nitrogen (liquid N_2).

3.9 **matrix** – sample medium (soil, water, vegetation, muscle, bone, etc.)

3.10 **percent abundance, isotopic abundance** – the ratio of the number of atoms of one isotope to the total number of atoms in a natural mixture of isotopes of the same element. Branching fractions are sometimes *incorrectly* labeled as "percent abundance."

3.11 **R value** – the ratio of observed activity divided by the actual amount of added activity, a measure of recovery.

3.12 **real time** – the time between the start of data acquisition and the end.

3.13 **volatility** – the susceptibility of a substance to convert from a liquid or solid state to a gaseous or vapor state by the application of heat, by reduction of pressure, or a combination of these processes.

NOTE: See *NAREL Common Terminology* (DR/T-1) for the definitions of other terms and acronyms used in this document.

4.0 ROLES AND RESPONSIBILITIES

4.1 Unless otherwise noted, counting room analysts are responsible for performing all steps of this procedure. These responsibilities include grouping samples into QC and assay batches, performing energy and efficiency calibrations, performing QC checks, and data review.

5.0 EQUIPMENT AND SUPPLIES

5.1 *Gamma-Ray Spectrometry System*

5.1.1 Detector Assembly - High-Purity Germanium (HPGe) detectors are used for gamma-ray spectrometry because of their fine peak energy resolution.

5.1.1.1 HPGe detector

5.1.1.2 Preamplifier

5.1.1.3 Cryostat

5.1.2 Detector Housing

5.1.2.1 Low-background shield

5.1.2.2 30 L Dewar

5.1.3 PC/Controller and Associated Electronics

5.1.2.3 Personal computer

5.1.2.4 Multichannel analyzer (MCA) with PC interface

5.1.2.5 Gamma spectrum analysis software

5.1.2.6 High-voltage bias supply

5.1.2.7 Spectroscopy amplifier

5.2 Sample containers such as Marinelli beakers, cottage cheese containers, glassine envelopes, etc.

6.0 REAGENTS AND STANDARDS

6.1 Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, when such specifications are available.

6.2 Nitric acid (HNO_3), 8 M. (CAS: 7697-37-2). Add a measured amount of concentrated (16 M) HNO_3 to an equal amount of deionized water. Mix well.

6.3 NIST-traceable calibration standards.

6.4 Liquid nitrogen (LN2).

6.5 Well-characterized laboratory control samples.

7.0 SAFETY

7.1 All procedures performed at NAREL must be conducted following the requirements detailed in the *NAREL Chemical Hygiene Plan* (HS/M-2) and the *NAREL Radiation Safety Manual* (HS/M-1). Safety precautions associated with handling of chemical reagents, solutions, and all samples are the primary responsibility of the analyst. Any spills or accidents involving hazardous, corrosive, or toxic material must be immediately resolved.

7.2 All NAREL laboratory personnel are expected to use good laboratory practices. Most of the safety training is provided by the SHEM officer. The analyst is expected to comply with all directives given by the SHEM officer, and must take necessary precautions to prevent exposure or injury to both self and co-workers.

7.3 Unnecessary or prolonged exposure to laboratory chemicals should be avoided.

7.4 Nitrogen remains liquefied only at extremely low temperatures. Skin exposed to a significant quantity of LN2 may freeze rapidly. Wear safety glasses, insulated gloves and lab coat when handling the LN2 tanks, dewars, and related equipment. Nitrogen can be an asphyxiant by displacing oxygen in air, so use only with adequate ventilation.

7.5 If needed, enclose liquid samples in plastic bags to prevent contamination of the detector and housing. The use of plastic bags is impractical on counting systems with automatic sample-loading mechanisms. Any sample that could leak and contaminate the detector should not be analyzed on these systems.

7.6 Nitric acid (HNO_3) is poisonous, reactive, and a strong oxidizer. Contact with other materials may cause fire. It can cause burns to body tissues and may be fatal if ingested or inhaled. Vapors are irritating to eyes and mucous membranes. Use only with adequate ventilation and proper protective clothing and gloves. Nitric acid is incompatible with most substances, especially strong bases, metallic powders, carbides, and combustible organics. Store away from light and heat.

7.7 Safety data sheets (SDSs) are available to all personnel involved in chemical analysis. It is the responsibility of each analyst to be familiar with chemicals used during an analysis.

7.8 Refer to the *NAREL Chemical Hygiene Plan* for verification of appropriate safety and health practices.

8.0 SAMPLE COLLECTION, PRESERVATION, AND STORAGE

8.1 Soil samples can be shipped to the laboratory in either plastic or glass containers. No preservation is required.

8.2 Water samples can be shipped in either plastic or glass containers. Nitric acid (HNO_3) should be added to the sample in the field to bring the pH to less than 2. Upon receipt of the samples, NAREL staff checks the pH of each water sample and adjusts the pH as necessary. If pH is adjusted, wail at least 16 hours prior to analysis.

Note: If analyzing for radioiodine, do not preserve the sample.

8.3 Special handling such as refrigeration or freezing may be required for samples of other matrices such as animal tissue or vegetation.

8.4 Soil and water samples for gamma analysis do not require refrigeration during storage. Samples must be stored in a safe and secure environment to maintain chain of custody.

9.0 CALIBRATION AND STANDARDIZATION

9.1 A detailed procedure for calibration is presented in the *NAREL Standard Operating Procedure for Calibration and Use of High-Purity Germanium Gamma-Ray Detectors Using Gamma Vision and Global Value* (NC/SOP-10).

9.2 *Energy and FWHM Calibrations*

9.2.1 Electronics are typically adjusted to produce an energy vs. channel curve of 0.25 keV per channel. Refer to NC/SOP-10 Section 9.3.6 for additional detail.

9.2.2 The equation parameters that define energy vs. channel and FWHM vs. channel for the software peak search and nuclide analysis routines should be re-determined in conjunction with, and prior to, each efficiency calibration.

9.3 *Efficiency Calibration*

9.3.1 Gamma-ray spectrometry counting geometries are calibrated using NIST-traceable standards in geometries identical to those used for samples. This means that the detector on which a sample is to be run must have been calibrated with a standard that was:

9.3.1.1 packaged in the same geometrical configuration as the sample,

9.3.1.2 positioned on the detector the same as the sample,

9.3.1.3 preferably the same matrix as the sample, and

9.3.1.4 approximately the same density as the sample (this consideration is especially important at lower energies). Refer to NC/SOP-10 Appendix 18.1 for guidance.

9.3.2 A detection efficiency vs. energy curve is determined for each geometry and for each detector that is to be used for sample analysis. Refer to NC/SOP-10, Section 10.1 for acceptance criteria.

9.3.3 When coincidence summing of gamma calibration photopeaks occurs, the measured efficiency for the photopeak energy determined by the commercial analysis software will be lower than the true value. This effect is most pronounced for geometries that place the sample close to the detector, and for N-type detectors where x-ray coincidence is also a factor. Whenever the net counts in sum peaks exceed one percent of the net counts in a peak used for efficiency calibration, the measured efficiency determined by the commercial analysis software shall be corrected using the formula in Section 13.3, then the detection efficiency vs. energy curve shall be re-determined using the corrected values.

9.3.4 Detection efficiencies are verified for each detector by counting a second NIST-traceable standard of the same geometry and analyzing it using the efficiency vs.

energy curve determined in the previous step. The results of this analysis are evaluated based on "Z scores" as described in the *Radiochemistry QA Manual*, Section 9.2.3. Whenever practical, the standard used for calibration verification should be obtained from a supplier other than the supplier of the standard used for the calibration itself. At a minimum the verification standard must come from a different lot. If the absolute value of the difference between the result obtained for the verification standard and the target value does not exceed three times the combined standard uncertainty of that difference, the result is considered acceptable. The calibration verification standard need not contain all the same gamma emitters as the calibration standard, but must contain nuclides that emit at least three gammas with energies near the low, middle, and high end of the range of energies for which the detector is calibrated. The verification standard must be counted long enough to obtain at least 10,000 net counts in each of the required three photopeaks.

9.4 *Background Determination*

9.4.1 Counts caused by radioactive constituents present at the counting location are minimized by enclosing the sample and detector in a low background shield. Corrections for background peaks in the spectrum are made on the basis of the peaks observed during a long detector background count. Three-thousand-minute detector background measurements are used for peak background correction and are performed monthly.

9.4.2 Peak areas of detected gamma decays are corrected for background developed by the interactions of sample radiation in the detector (e.g., Compton). This background is separate from the background radiation in the counting room.

NOTE: The detector background counts are in no way related to the natural background of the location from which the sample was taken.

10.0 PROCEDURE

10.1 Based on available sample size, place the sample to be analyzed in a container for a calibrated geometry. Normally, choose a geometry that provides the highest detection efficiency unless the gamma-ray emission rate is such that it causes a high dead time rate. A high dead time rate (i.e., greater than 10 %) may be reduced by selecting a less efficient geometry and/or detector.

10.2 If the sample is liquid and the detector does not have an automatic sample-loading mechanism, the sample may be enclosed in a plastic bag to avoid spillage that might contaminate the detector.

10.3 Open the shield and place the filled sample container in position atop the detector, using a sample holder if necessary to ensure the proper geometric relationship.

10.4 Close and latch the shield.

10.5 Using commercially available software, set the desired live time or a preset minimum detectable activity (MDA) and start the acquisition of data. A live time of 1000 minutes is typically used. However, the live time may be adjusted due to detector efficiency or a client/project requested MDA.

10.6 When the acquisition is complete, the software automatically transfers the counting data from the MCA to an electronic file and performs data analysis.

10.7 When an isotope is quantified in a sample that is known to be incorrectly quantified by the commercial analysis software due to summing of gamma cascade photopeaks, such as

^{134}Cs, the activity computed by the gamma analysis software shall be corrected using the formula in section 13.2.

11.0 RECORDS MANAGEMENT

11.1 The following gamma analysis logbooks are maintained and stored in the counting room:

11.1.1 NAREL Germanium Detector Quality Control and Contamination Check

11.1.2 HPGe Instrument Log for Individual Detectors

11.1.3 Gamma Analyst Logbook.

11.2 Records generated for energy and efficiency calibrations and long background counts are maintained in the counting room's office space.

11.3 Records and control charts generated for Laboratory Control Samples (LCS) are maintained in the Laboratory Information Management System (LIMS).

11.4 Records and control charts generated for QC checks and contamination checks are accessible via the instrument software system (Global Value) and are maintained on the laboratory server.

11.5 Records generated during review of gamma-ray spectrometry sample data are maintained by the Radiochemistry Data Coordinator (RDC).

12.0 QUALITY CONTROL PROCEDURES

12.1 Reference standards used to provide spiking solutions, standards, or calibration sources must be obtained from the National Institute of Standards and Technology (NIST) or suppliers who participate in supplying NIST standards or NIST-traceable radionuclides.

12.2 For each QC batch of up to 20 samples of the same matrix, the analyst must add the following quality control samples:

12.2.1 Method blank

12.2.1.1 A method blank shall be prepared using a calibrated counting geometry similar to that used for the samples. The container of the appropriate geometry can be empty or filled to similar volume to partially simulate gamma attenuation due to a sample matrix.

12.2.2 Laboratory control sample (LCS)

12.2.2.1 The laboratory control sample shall contain isotopes that represent the low (e.g., ^{241}Am), medium (e.g., ^{137}Cs) and high (e.g., ^{60}Co) energy range of the analyzed gamma spectra. As indicated by these examples the isotopes need not exactly bracket the calibrated energy range or the range over which isotopes are identified and quantitated. The laboratory control sample shall be prepared with similar aliquot size to that of the routine samples for analyses.

12.2.2.2 The activity of an analyte added to the LCS must be at least ten times the normal expected minimum detectable activity (MDA) for that analyte. The spike level should be high enough to ensure that under expected measurement conditions, the relative standard counting uncertainty will not exceed 5 %.

12.2.2.3 Appendix 19.1 contains procedures for annual recertification of gamma LCSs.

12.2.3 Replicate sample (duplicate)

12.2.3.1 If the sample aliquot consists of the entire available sample in order to provide the highest counting efficiency as stated in paragraph 2.3 of this procedure, then a replicate analysis of the sample shall be performed using a different detector in lieu of analyzing a replicate aliquot.

12.3 Analysts maintain control chart results for laboratory control samples, and observe the control charts for indicators of possible problems in the measurement system. LIMS software allows the analyst to input data points and to view and print the control charts.

12.4 See the *NAREL Radiochemistry Quality Assurance Manual* (QA/QAM-1) for acceptance criteria for QC samples, and equations for calculating values for quality indicators.

12.5 If a QC analysis fails, prepare and submit a Corrective Action Report, perform a root-cause investigation, and take corrective action that addresses the root cause. Simply repeating the QC analysis until the results meet acceptance criteria does not constitute corrective action, and is not permitted. If the cause of the failure is not determined, one must assume that whatever caused the failure may have adversely affected sample results too. Options in this case include reanalyzing the entire batch or reporting the original results, with the failed QC results, and with appropriate notices and warnings in the report's narrative. The choice of options will depend on the project and on the preferences of the client and the Analytical Services Coordinator, who represents the client's interests at the laboratory. The analyst must contact the Analytical Services Coordinator to determine whether the batch is to be reanalyzed or reported with warnings.

12.6 A QC check source with nuclides that emit gamma-rays at three widely-spaced energies is assigned to each detector. The energies are representative of the low, middle, and high ranges that the detector is calibrated for, but do not need to fully bracket the calibrated range. The low-energy nuclide is typically ^{210}Pb for detectors with beryllium or synthetic fiber windows, or ^{241}Am for detectors with aluminum or magnesium windows. The mid-energy and high-energy nuclides are typically ^{137}Cs and ^{60}Co, respectively. The activity of each nuclide should be adequate to accumulate at least 10,000 counts in each of the three photopeaks when the source is first assigned to the detector. A QC check source must be replaced when it decays to the extent that at least 2,500 net counts in each photopeak cannot be obtained when counted for no more than one hour.

12.6.1 Tolerance limits for each of the three energies are established for peak center channel, corresponding to a gamma-ray energy of 1 keV above or below the value determined during calibration.

12.6.2 Tolerance limits for each of the three energies are established for FWHM, at 30 % above and below the mean.

12.6.3 Warning and control limits for efficiency, activity, or net peak counts at each of the three energies are determined in accordance with the instructions for "Other Normally Distributed Parameters" in QA/G-1, *NAREL Guide for the Use of Control Charts and Tolerance Charts.*

12.7 The following QC checks must be performed at least weekly for each detector. For single-sample detectors, the QC checks must also be performed each day before and after a detector is used to count samples. For detectors with automatic sample changers, the QC checks are performed weekly and before and after counting each load of samples.

12.7.1 Count the QC check source, and then determine and plot on a control chart or tolerance chart the peak centroid channel, FWHM, and either efficiency, activity, or net peal counts for each of the three energies. Review and evaluate the results. Investigate whenever a control or tolerance limit is exceeded, and take corrective action as necessary.

12.7.2 Check for radioactive contamination of the detector and shield by counting for 20 minutes with nothing but the detector and sample positioning aids in the shield. The shield door shall be closed for this measurement. Determine and plot on a control chart the total counts in the entire gamma energy spectrum. Review and evaluate the results. Investigate and take corrective action as required whenever a control limit is exceeded.

12.8 All quality control data must be maintained and available for easy reference or inspection.

13.0 DATA ANALYSIS AND CALCULATIONS

13.1 Using commercially available software, analyze the sample data and calculate radionuclide activities.

13.2 If an isotope known to be incorrectly quantified by the commercial analysis software due to summing of gamma cascade photopeaks, such as ^{134}Cs, is measured in a sample, correct the activity, MDA, critical value and uncertainty reported by the analysis software using the following formula:

$$A_{ci} = x_i \frac{A_i}{C_i} \quad (1)$$

where

A_{ci} is the cascade summing corrected activity of the isotope in the sample,
x_i is the activity of the isotope in the sample as reported by the commercial analysis software,
A_i is the certified activity of the standard containing only the isotope, counted in the same geometry and on the same detector,
C_i is the activity of the isotope in the standard containing only the isotope, as reported by the commercial analysis software, and

NOTE: The use of equation 1 to correct the uncertainty of the result is known to underestimate the corrected uncertainty by omitting the component of uncertainty due to the correction factor itself.

13.3 Correct the measured efficiency for photopeaks in calibration spectra and sample spectra for coincidence summing losses using the following formula:

$$E_{cp} = E_{mp} \frac{C_p + C_{s1} + C_{s2} + C_{s3} + C_{s...}}{C_p} \quad (2)$$

where

E_{cp} is the coincidence summing corrected efficiency at the photopeak energy,
E_{mp} is the measured efficiency at the photopeak energy determined by the commercial analysis software,
C_p is the net counts in the primary photopeak, and
$C_{s1}, C_{s2}, C_{s3}, C_{s...}$, are the net counts in each of the sum photopeaks associated with the primary photopeak.

14.0 DATA REVIEW

14.1 See the *NAREL Standard Operating Procedure for Review of Radiochemistry Data* (DR/SOP-2) for general procedures for data review.

14.2 The gamma-ray spectrometry system administrator or another person authorized by the Counting Room Team Leader performs the first official review of analytical results using review software to mark the results as acceptable or unacceptable and to store them in the LIMS database.

14.3 The instrument operator should check for data entry errors such as collection date and time, analysis quantity, efficiency file, library and background correction file even if he or she is not the designated first reviewer.

14.4 The instrument operator and the data reviewers must monitor the results of instrument efficiency checks. Failed checks require corrective action, which must be documented in the instrument logbook.

14.5 The data reviewer must check that the total dead time for the acquisition was not more than 10 % of the real time. If this dead time limit is exceeded, the sample should be reanalyzed either in a different geometry or with a smaller subsample to reduce the dead time to an acceptable level. If it is not feasible to reanalyze the sample, all the results must be qualified by the data reviewer (J or R qualifier depending on severity).

14.6 For gamma analyses, the reviewer should inspect the results of the analysis, giving particular attention to the reasonableness of the activities of naturally-occurring radionuclides and of the activity ratios for related gamma-ray emitters (e.g., parents and progeny).

14.7 The calibration geometry must be checked for each sample. If the wrong calibration curve has been used, the data analysis must be repeated using a more appropriate calibration.

NOTE: The gamma review software automatically checks that the sample volume and density are consistent with the calibration geometry and warns the reviewer if they are not.

14.8 It is unusual to find "light elements," or gamma-emitting radionuclides with atomic mass numbers less than 200, in environmental media, since most of these nuclides are short-lived and do not occur naturally. Gamma-ray photopeaks from naturally occurring radionuclides may be misidentified as light elements. The reviewer should double-check the results if light elements other than ^{7}Be, ^{137}Cs, and ^{40}K are identified in a sample. If peaks have been misidentified, the incorrect results must be R-flagged or the data analysis must be repeated with software and library settings that give correct identifications.

NOTE: The gamma-review software automatically checks for these unusual light elements and warns the reviewer if they are present.

14.9 Other unusual nuclides include ^{207}Bi and ^{203}Hg. If one of these nuclides has been identified by the gamma analysis software, the data reviewer should confirm its presence by reviewing the spectrum and the full data report. If the nuclide identification is found to be incorrect, the result is R-qualified or the data analysis is repeated with software and library settings that provide correct identifications.

14.10 Since several radionuclides from one decay series may be gamma emitters, reviewers should check that the nuclides are approximately in radioactive equilibrium unless there are reasons to suspect that the equilibrium has been disturbed. For example:

14.10.1 In most solid samples, ^{228}Ra, ^{212}Pb, and ^{212}Bi should be in equilibrium, with ^{208}Tl at about 34 % of the other values.

14.10.2 ^{214}Pb and ^{214}Bi should always be in equilibrium.

14.11 The reviewer must attempt to identify or explain all gamma-ray photopeaks not identified by the gamma analysis software. This step may be omitted if the sample is from a site where only naturally-occurring nuclides are expected and ^{226}Ra and/or ^{228}Ra are present at concentrations greater than 50 pCi/g. Sum peaks and escape peaks may not always be easily identifiable.

14.11.1 If a peak has been placed in the unknown peak list that is in the library, a slight energy shift may have occurred. In this instance the peak match width may be increased in increments of 0.1 to ensure that all known peaks are properly identified.

14.12 If an unusual, unidentified, or otherwise questionable photopeak is found in a gamma-ray spectrum, the reviewer should consult a standard reference such as Laboratoire National Henri Becquerel, Nucleide.org, or the Department of Energy's Nuclear Structure and Decay Database, NuDat to confirm the identity of the peak. If the peak cannot be explained, the sample may be recounted for confirmation.

14.13 If the presence of an unusual nuclide is confirmed in an ERAMS or RadNet sample, the data reviewer must submit an ERAMS/RadNet Event Report to the ERAMS/RadNet Manager.

14.14 For routine gamma-ray analyses, NAREL qualifies results for ^{214}Bi, ^{214}Pb, ^{212}Bi, ^{212}Pb and ^{208}Tl as "estimated" (J qualifier), because they are short-lived and cannot be properly decay-corrected without knowing whether they are in radioactive equilibrium with their parent radionuclides. NAREL also routinely qualifies results for ^{226}Ra, ^{234}Th, and ^{235}U with a J code because of the likelihood of spectral interferences.

15.0 METHOD PERFORMANCE

15.1 NAREL has participated for many years in proficiency-testing studies for gamma-emitting radionuclides in soil, water, vegetation, and on filter papers. Results from some recent studies are summarized below.

Ref Date	Source	Matrix	Nuclide	Rpt	Unc	True Value	TV Unc	% R	Z Score
8/1/2011	MAPEP	soil	Co-57	1314	144.54	1180.000	59	1.11	0.86
8/1/2011	MAPEP	water	Co-57	34.2	4.104	36.600	1.83	0.93	-0.53
8/1/2011	MAPEP	filter	Co-57	5.12	0.6144	5.090	0.2545	1.01	0.05
2/1/2012	MAPEP	soil	Co-57	1150	138	1179.000	58.95	0.98	-0.19
2/1/2012	MAPEP	water	Co-57	35.4	4.248	32.900	1.645	1.08	0.55
2/1/2012	MAPEP	veg	Co-57	15.3	1.836	12.000	0.6	1.28	1.71
8/1/2012	MAPEP	soil	Co-57	1570	188.4	1316.000	65.8	1.19	1.27
8/1/2012	MAPEP	water	Co-57	31.1	3.732	29.300	1.465	1.06	0.45
8/1/2012	MAPEP	filter	Co-57	1.74	0.2088	1.910	0.0955	0.91	-0.74
8/1/2012	MAPEP	veg	Co-57	7.2	0.864	5.660	0.283	1.27	1.69
2/1/2013	MAPEP	water	Co-57	32	3.84	30.900	1.545	1.04	0.27
2/1/2013	MAPEP	filter	Co-57	2.3	0.276	2.360	0.118	0.97	-0.20
2/1/2013	MAPEP	veg	Co-57	8.56	1.0272	8.680	0.434	0.99	-0.11

Ref Date	Source	Matrix	Nuclide	Rpt	Unc	True Value	TV Unc	% R	Z Score
2/1/2012	MAPEP	filter	Co-60	1.96	0.2156	2.182	0.1091	0.90	-0.92
2/1/2012	MAPEP	veg	Co-60	6.19	0.6809	6.050	0.3025	1.02	0.19
10/5/2012	ERA	water	Co-60	79.8	8.778	78.300	3.915	1.02	0.16
9/27/2012	ERA	soil	Co-60	4230	465.3	4310.000	215.5	0.98	-0.16
9/27/2012	ERA	veg	Co-60	2180	239.8	2030.000	101.5	1.07	0.58
9/27/2012	ERA	filter	Co-60	485	53.35	521.000	26.05	0.93	-0.61
9/27/2012	ERA	water	Co-60	1260	138.6	1260.000	63	1.00	0.00
8/1/2012	MAPEP	soil	Co-60	557	61.27	531.000	26.55	1.05	0.39
8/1/2012	MAPEP	filter	Co-60	1.58	0.1738	1.728	0.0864	0.91	-0.76
8/1/2012	MAPEP	veg	Co-60	5.23	0.5753	5.120	0.256	1.02	0.17
2/1/2013	MAPEP	soil	Co-60	700	77	691.000	34.55	1.01	0.11
2/1/2013	MAPEP	water	Co-60	19.1	2.101	19.560	0.978	0.98	-0.20
2/1/2013	MAPEP	veg	Co-60	5.46	0.6006	5.850	0.2925	0.93	-0.58
3/18/2013	ERA	soil	Co-60	7560	831.6	7920.000	396	0.95	-0.39
3/18/2013	ERA	veg	Co-60	2140	235.4	1920.000	96	1.11	0.87
3/18/2013	ERA	filter	Co-60	207	22.77	214.000	10.7	0.97	-0.28
10/5/2012	ERA	water	Cs-137	1.82	0.2002	1.790	0.0895	1.02	0.14
9/27/2012	ERA	soil	Cs-137	184	20.24	183.000	9.15	1.01	0.05
9/27/2012	ERA	veg	Cs-137	3680	404.8	3470.000	173.5	1.06	0.48
9/27/2012	ERA	filter	Cs-137	2320	255.2	2070.000	103.5	1.12	0.91
9/27/2012	ERA	water	Cs-137	809	88.99	793.000	39.65	1.02	0.16
8/1/2012	MAPEP	soil	Cs-137	2100	231	2040.000	102	1.03	0.24
8/1/2012	MAPEP	water	Cs-137	1330	146.3	1150.000	57.5	1.16	1.15
8/1/2012	MAPEP	veg	Cs-137	17.6	1.936	16.700	0.835	1.05	0.43
2/1/2013	MAPEP	soil	Cs-137	4.85	0.5335	4.380	0.219	1.11	0.81
2/1/2013	MAPEP	filter	Cs-137	637	70.07	587.000	29.35	1.09	0.66
2/1/2013	MAPEP	veg	Cs-137	2.66	0.2926	2.600	0.13	1.02	0.19
3/18/2013	ERA	soil	Cs-137	7.01	0.7711	6.870	0.3435	1.02	0.17
3/18/2013	ERA	veg	Cs-137	6050	665.5	6120.000	306	0.99	-0.10
3/18/2013	ERA	filter	Cs-137	623	68.53	544.000	27.2	1.15	1.07

Ref Date	Source	Matrix	Nuclide	Rpt	Unc	True Value	TV Unc	% R	Z Score
3/18/2013	ERA	water	Cs-137	963	105.93	940.000	47	1.02	0.20
4/8/2013	ERA	water	Cs-137	1960	215.6	1880.000	94	1.04	0.34

16.0 POLLUTION PREVENTION

16.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity and/or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA places pollution prevention as the management option of first choice.

17.0 WASTE MANAGEMENT

17.1 The EPA requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. It is the responsibility of each laboratory to assure adherence to EPA regulations. Specific information can be found in the *NAREL Chemical Hygiene Plan.*

17.2 Waste streams generated by this procedure include low-level radioactive waste from the proper disposition of calibration standards when they expire.

18.0 REFERENCES

18.1 *NAREL Standard Operating Procedure for Calibration and Use of High-Purity Germanium Gamma-Ray Detectors Using Gamma Vision and Global Value* (NC/SOP-10).

18.2 *NAREL Radiochemistry Quality Assurance Manual* (QA/QAM-1).

18.3 *NAREL Guide for the Use of Control Charts and Tolerance Charts* (QA/G-1).

18.4 *NAREL Standard Operating Procedure for Review of Radiochemistry Data* (DR/SOP-2).

18.5 *NAREL Standard Operating Procedure for Document Control* (QA/SOP-1).

18.6 *NAREL Radiation Safety Manual* (HS/M-1).

18.7 *NAREL Chemical Hygiene Plan* (HS/M-2).

18.8 *NAREL Common Terminology* (DR/T-1).

19.0 APPENDICES (TABLES, DIAGRAMS, AND FLOWCHARTS)

19.1 LCS Recertification Procedure.

Appendix 19.1

LCS Recertification Procedure

The laboratory control samples (LCSs) used by CERLS for gamma analysis are standard radionuclide sources containing ^{207}Bi-207 and ^{155}Eu. The manufacturer typically places a one-year expiration date on each standard. However, the half-lives of both ^{207}Bi-207 and ^{155}Eu are long enough to allow the use of each standard well beyond its nominal one-year expiration date. CERLS continues to use these standards as LCSs based on acceptable annual recertification. The annual recertification is performed by the following method:

1. Each LCS standard is analyzed annually for recertification.
2. The analyst compares the certified activity provided by the manufacturer to the measured activity using a Z test with warning limits of ±2 and control limits of ±3. If the Z score exceeds ±3, the standard may not be used. If it exceeds ±2, a second measurement must be performed. If the second Z score exceeds ±2, the standard may not be used.
3. The HPGe administrator verifies that the decay-corrected standard activities will not fall below 10 times the MDA for any of the primary photopeaks during the coming year.
4. The gamma analyst or HPGe administrator examines all standards to ensure the physical integrity of the container and the standard matrix.
5. The new expiration date is one year from the date of analysis.
6. All of the above work is documented and submitted to the Counting Room Team Leader for approval.
7. All of the above work is kept as records and stored with the HPGe calibration records.
8. Upon approval, the gamma analyst places a label on the standard referencing the updated/new expiration date.

Attachment B

Radiation Methods

Radiation Methods

While not directly relevant to this memorandum, various radiation methods for Ra-226 analysis have historically been used for media at Midnite Mine and while the numerical method is listed in the QAPPs, the actual methodology may not be described. Radiation Methods (excerpted from EPA's 1998 *Compendium of EPA-Approved Analytical Methods for Measuring Radionuclides in Drinking Water*) that have appeared in Midnite Mine documents include those listed below:

- **Method 903.1** - Radium in Drinking Water, Radon Emanation Technique
  Reference: Prescribed Procedures for Measurement of Radioactivity in Drinking Water, EPA 600/4-80-032, prepared by EPA's Environmental Monitoring and Support Laboratory, August 1980. Available from U.S. Department of Commerce, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, document no. PB 80-224744.
  Methodology: Radon-emanation; count alpha by scintillation counter. [Method modified for soil analysis.]
  Comments: This method is specific for radium-226.

- **Method Ra-04** - Radiochemical Determination of Radium-226, De-emanation Procedure
  Reference: Radiochemistry Procedures Manual, EPA 520/5-84-006, prepared by EPA's Eastern Environmental Radiation Facility, August 1984. Available from NTIS, document no. PB 84-215581.
  Methodology: Radon-emanation; count alpha by scintillation counting.
  Comments: None.

- **Method Ra-02** - Determination of 226Ra and 228Ra
  Reference: Determination of Ra-226 and Ra-228 (Ra-02), January 1980, Revised June 1982. Available from Radiological Sciences Institute Center for Laboratories and Research, New York State Department of Health, Empire State Plaza, Albany, NY 12201.
  Methodology: Radon emanation (for radium-226); count alpha by scintillation cell for radium-226 and by beta/gamma coincidence counter for radium-228.
  Comments: This method can measure radium-226 alone or radium-226 in conjunction with radium-228. The radium solution from the radium-226 determination is saved and the radium is reprecipitated for radium-228 analysis.

- **Method Ra-03** - Radiochemical Determination of Radium-226 in Water Samples
  Reference: Radiochemistry Procedures Manual, EPA 520/5-84-006, prepared by EPA's Eastern Environmental Radiation Facility, August 1984. Available from NTIS, document no. PB 84-215581.
  Methodology: Radiochemical/precipitation; alpha counting by scintillation counter.
  Comments: None.

One additional Ra-226 method has been referenced:

- **DOE HASL 300.** DOE HASL 300 (gamma spectrometry method) includes all the gamma emitting isotopes including Ra-226. This is the industry standard for radiological analysis in soil. DOE HASL 300 has an enormous number of modules. It also has an RA-01 and an RA-04 (both only radium-226 analysis).

Attachment C

Source: Midnite Mine Remedial Investigation Report, Appendix D (URS 2005)

In Attachment C, Radium 226 results are provided for each sample and they are labelled “Radium 226, Calculated Total.” These data values are the values that were used to calculate background cleanup levels at the Site. These data values are Radium 226 total concentrations and they were not “calculated.”

See further discussion on this issue in Attachment D.

Analytical Results for URS Background Mineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKMIN-01 60900 09/28/00 0 - 0.16	SMBKMIN-02 60901 09/28/00 0 - 0.16	SMBKMIN-03 60902 09/28/00 0 - 0.16	SMBKMIN-04 60903 09/28/00 0 - 0.16	SMBKMIN-05 60904 09/29/00 0 - 0.16	SMBKMIN-06 60905 09/29/00 0 - 0.16
Inorganics, mg/kg						
Chloride	5.69	5.8	3.2	2.87	5.52	3.87
Nitrate	---- R	---- R	---- R	0.02 J	---- R	0.023 J
Nitrite	0.2 UJ	0.02 UJ	0.02 UJ	0.02 U	0.02 U	0.02 U
Nitrogen, Ammonia	2.34 J	2.24 J	1.68 J	2.53 J	2.13 J	4.26 J
Phosphate-P	15.8 J	17 J	3.93 J	5.81 J	10 J	11 J
Phosphorus	1110	1530	511	620	826	791
Sulfate	6.73 J	6.15 J	3.23 J	5.43	5.09	7.02
Metals, mg/kg						
Aluminum Total	14900	15700	14600	24100	21400	22500
Antimony Total	1.1 J	1.3 J	1 J	0.73 UJ	0.93 UJ	0.81 UJ
Arsenic Total	30.3	31.1	62.6	76.2	41.1	29.3
Barium Total	354	384	263	266	336	295
Beryllium Total	0.7	0.69	0.87	1.1	0.81	0.87
Cadmium Total	0.32 J	0.26 J	0.23 J	0.32 J	0.34	0.38
Calcium Total	5710 J	6690 J	4550 J	6510	5780	8100
Chromium Total	12.2	9	10.9	18.2	13.4	14.7
Cobalt Total	9.9	8.7	13.7	21.6	8.7	23.8
Copper Total	21	22.8	23.7	41.8	22.3	26.4
Iron Total	20300	19300	24100	32600	24400	24500
Lead Total	13.8	15.8	12.7	14.7	16	13.2
Magnesium Total	2120	1830	1690	2280	2160	2550
Manganese Total	1070	881	761	758	718	1070
Mercury Total	0.05 U	0.04 U	0.04 U	0.05 U	0.05 U	0.04 U
Molybdenum Total	0.93 J	1.2 J	1.1 J	2.1 J	1.3 J	1.5 J
Nickel Total	16	13.4	16.4	24	15.1	19.8
Potassium Total	2010	1600	1810	2370	2120	2460
Selenium Total	0.66 U	0.79 U	0.56 U	0.28 U	0.25 U	0.27 U
Silver Total	0.1 U	0.1 U	0.09 U	0.09 U	0.08 U	0.09 U
Sodium Total	164	251	145	204	295	256
Thallium Total	0.14 J	0.12 J	0.2 J	0.26 J	0.14 J	0.23 J
Uranium, Calculated Total	2.6	2.56	3.13	4.93	2.7	3.17
Vanadium Total	26.5	19.6	26.7	38.7	35	36.8
Zinc Total	52.2	50.6	32.6	46	44.7	51.2

Analytical Results for URS Background Mineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: Sample ID: Sample Date: Sample Depth (ft.): Parameter	SMBKMIN-01 60900 09/28/00 0 - 0.16	SMBKMIN-02 60901 09/28/00 0 - 0.16	SMBKMIN-03 60902 09/28/00 0 - 0.16	SMBKMIN-04 60903 09/28/00 0 - 0.16	SMBKMIN-05 60904 09/29/00 0 - 0.16	SMBKMIN-06 60905 09/29/00 0 - 0.16
Other Parameters						
Alkalinity, Total, mg/kg	122 J	126 J	126 J	142 J	136 J	175 J
Bicarbonate Alkalinity, mg/kg	122	126	126	142	136	175
Carbonate Alkalinity, mg/kg	9 U	9 U	9 U	9 U	9 U	9 U
pH, SU	6.52	6.67	6.92	6.72	6.03	6.64
Total Organic Carbon, mg/kg	51050	51050	34300	59600	66000	66700
Radionuclides, pCi/g						
Lead 210 Total	3.8 +/- 1.9	3.8 +/- 2.	1.1 +/- 1.7 U	3 +/- 1.8	3.5 +/- 2.	2.5 +/- 1.8 U
Polonium 210 Total	2.3 +/- 0.7	3.1 +/- 1.	2.8 +/- 0.8	2.9 +/- 0.8	4.1 +/- 1.1	2.9 +/- 0.9
Radium 226, Calculated Total	1.57 +/- 0.11	1.78 +/- 0.11	1.89 +/- 0.12	2.16 +/- 0.13	1.97 +/- 0.13	1.69 +/- 0.11
Radium 228 Total	1.23 +/- 0.096	1.09 +/- 0.083	1.48 +/- 0.098	1.61 +/- 0.11	1.22 +/- 0.1	1.3 +/- 0.092
Thorium 227 Total	0.0417 +/- 0.1 U	0.123 +/- 0.092	0.17 +/- 0.12	0.076 +/- 0.077 U	0.0625 +/- 0.061 U	0.0613 +/- 0.064 U
Thorium 228 Total	1.03 +/- 0.22	1.17 +/- 0.23	1.61 +/- 0.22	1.4 +/- 0.21	1.02 +/- 0.19	1.08 +/- 0.19
Thorium 230 Total	1.18 +/- 0.22 J	1.17 +/- 0.2 J	1.26 +/- 0.17 J	1.54 +/- 0.19	1.07 +/- 0.16	1.21 +/- 0.17
Thorium 232 Total	1.09 +/- 0.21	0.974 +/- 0.18	1.35 +/- 0.18	1.22 +/- 0.17	1.13 +/- 0.17	1.11 +/- 0.16
Uranium 234 Total	0.965 +/- 0.17	1.09 +/- 0.18	1.18 +/- 0.2	1.6 +/- 0.25	0.92 +/- 0.16	1.07 +/- 0.18
Uranium 235 Total	0.119 +/- 0.06	0.115 +/- 0.061	0.124 +/- 0.067	0.106 +/- 0.065	0.0668 +/- 0.047	0.0891 +/- 0.052
Uranium 238 Total	0.853 +/- 0.15	0.841 +/- 0.16	1.03 +/- 0.18	1.64 +/- 0.25	0.897 +/- 0.16	1.05 +/- 0.17

Analytical Results for URS Background Mineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKMIN-07 60906 09/29/00 0 - 0.16	SMBKMIN-08 60907 09/29/00 0 - 0.16	SMBKMIN-09 60908 09/29/00 0 - 0.16	SMBKMIN-10 60909 09/30/00 0 - 0.17	SMBKMIN-11 60928 09/30/00 0 - 0.17	SMBKMIN-12 60929 10/01/00 0 - 0.16
Inorganics, mg/kg						
Chloride	17.9	10.3	3.76	2.71	2.54	4
Nitrate	0.772 J	0.166 J	---- R	---- R	---- R	0.024 J
Nitrite	0.02 U	0.02 U	0.02 U	0.02 U	0.049	0.02 U
Nitrogen, Ammonia	4.57 J	2.75 J	1.96 J	1.97 J	2.25 J	2.05 J
Phosphate-P	16 J	17.8 J	12.5 J	7.99 J	10.7 J	0.314 J
Phosphorus	781	719	754	671	606	441
Sulfate	17.3	7.1	5.19	4.61	4.95	5.63
Metals, mg/kg						
Aluminum Total	20900	20100	16100	21800	16300	8230
Antimony Total	0.63 UJ	0.83 UJ	1.4 UJ	1.4 UJ	0.68 UJ	0.92 UJ
Arsenic Total	23.3	17.5	94.6	89.1	234	88.2
Barium Total	342	355	214	251	135	143
Beryllium Total	0.7	0.77	0.58	0.85	0.94	0.33 J
Cadmium Total	0.44	0.38	0.29 J	0.45	0.18 J	0.11 J
Calcium Total	8670	6640	4510	6150	3890	3310
Chromium Total	13.5	12.4	12.9	15	14.8	6.1
Cobalt Total	12.5	9.7	6	9.7	8.3	2.8 J
Copper Total	23.8	21	36.9	36.8	25.4	23.1
Iron Total	21200	21400	21600	29800	28700	14400
Lead Total	18.4	16.4	15.1	11.4	12	9.2
Magnesium Total	2580	2190	1600	2130	1960	1280
Manganese Total	1260	1060	573	666	332	254
Mercury Total	0.05 U	0.05 U	0.05 U	0.05 U	0.04 U	0.05 U
Molybdenum Total	1.3 J	1.2 J	2.6 J	2.8 J	2 J	3.4 J
Nickel Total	16.2	12	9.3	18.8	14	5.6
Potassium Total	2380	2270	1670	2360	1830	1100
Selenium Total	0.29 U	0.27 U	0.28 U	0.29 U	0.3 U	0.23 U
Silver Total	0.1 U	0.09 U	0.09 U	0.1 U	0.1 U	0.08 U
Sodium Total	273	289	170	187	136	55.6
Thallium Total	0.3 J	0.16 J	0.13 J	0.13 J	0.12 J	0.1 J
Uranium, Calculated Total	2.77	2.32	3.54	4.06	13.3	4.61
Vanadium Total	33.9	32.1	30.6	41.8	30.1	15.3
Zinc Total	55.3	52.3	36.3	38.2	29	17.2

Analytical Results for URS Background Mineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKMIN-07 60906 09/29/00 0 - 0.16	SMBKMIN-08 60907 09/29/00 0 - 0.16	SMBKMIN-09 60908 09/29/00 0 - 0.16	SMBKMIN-10 60909 09/30/00 0 - 0.17	SMBKMIN-11 60928 09/30/00 0 - 0.17	SMBKMIN-12 60929 10/01/00 0 - 0.16
Other Parameters						
Alkalinity, Total, mg/kg	165 J	133 J	206 J	138 J	129	81.9 J
Bicarbonate Alkalinity, mg/kg	165	133	206	138	129 J	81.9
Carbonate Alkalinity, mg/kg	9 U	9 U	9 U	9 U	9 U	9 U
pH, SU	6.45	5.88	6.63	6.92	6.83	5.6
Total Organic Carbon, mg/kg	70250	83150	43450	47200	29250	41450
Radionuclides, pCi/g						
Lead 210 Total	2.8 +/- 1.9	4.2 +/- 1.9	4.7 +/- 2.	2.9 +/- 1.7	8.2 +/- 1.9	2.6 +/- 1.6 U
Polonium 210 Total	5.5 +/- 1.4	4.6 +/- 1.2	3.7 +/- 0.9	2.4 +/- 0.7	7.9 +/- 2.	2.8 +/- 1.
Radium 226, Calculated Total	1.87 +/- 0.12	1.65 +/- 0.1	1.85 +/- 0.11	2.21 +/- 0.13	8.24 +/- 0.47	2.25 +/- 0.14
Radium 228 Total	1.23 +/- 0.09	1.19 +/- 0.081	1.49 +/- 0.1	1.71 +/- 0.11	1.78 +/- 0.12	1.82 +/- 0.12
Thorium 227 Total	0.0703 +/- 0.096 U	0.119 +/- 0.086	0.0805 +/- 0.073 U	0.0992 +/- 0.081 U	0.227 +/- 0.13	0.0714 +/- 0.074 U
Thorium 228 Total	1.11 +/- 0.23	1.1 +/- 0.21	1.48 +/- 0.25	1.71 +/- 0.23	1.47 +/- 0.25	1.95 +/- 0.29
Thorium 230 Total	0.88 +/- 0.16	1.03 +/- 0.17	1.41 +/- 0.21	1.55 +/- 0.19	4.59 +/- 0.42	1.64 +/- 0.23
Thorium 232 Total	0.982 +/- 0.17	1.01 +/- 0.17	1.5 +/- 0.21	1.52 +/- 0.19	1.37 +/- 0.21	1.38 +/- 0.21
Uranium 234 Total	1.04 +/- 0.19	0.784 +/- 0.15	1.29 +/- 0.19	1.21 +/- 0.19	4.37 +/- 0.47	1.79 +/- 0.23
Uranium 235 Total	0.0748 +/- 0.055	0.0342 +/- 0.041 U	0.125 +/- 0.061	0.206 +/- 0.082	0.362 +/- 0.13	0.305 +/- 0.097
Uranium 238 Total	0.917 +/- 0.18	0.779 +/- 0.15	1.17 +/- 0.18	1.33 +/- 0.2	4.42 +/- 0.47	1.5 +/- 0.21

Analytical Results for URS Background Mineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKMIN-13 60930 10/01/00 0 - 0.16	SMBKMIN-14 60931 10/01/00 0 - 0.16	SMBKMIN-15 60932 10/01/00 0 - 0.16	SMBKMIN-16 60933 10/02/00 0 - 0.16	SMBKMIN-17 60934 10/02/00 0 - 0.16	SMBKMIN-18 60935 10/02/00 0 - 0.16
Inorganics, mg/kg						
Chloride	7.63	8.58	4.71	4.28	4.29	3.82
Nitrate	---- R	0.023 J	0.026 J	---- R	0.021 J	0.02 J
Nitrite	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
Nitrogen, Ammonia	2.25 J	2.31 J	1.51 J	2.6 J	4.28 J	2.58 J
Phosphate-P	11 J	5.25 J	12.3 J	8.49 J	20.6 J	16.7 J
Phosphorus	844	531	919	497	835	1180
Sulfate	7.61	17.1	5.17	9.28	9.22	8.04
Metals, mg/kg						
Aluminum Total	20800	13200	19100	17300	19400	20000
Antimony Total	1.2 UJ	0.96 UJ	1.1 UJ	0.73 UJ	0.98 UJ	1.1 UJ
Arsenic Total	64.7	144	3.1 J	13	18.1	27.5
Barium Total	331	189	357	312	342	366
Beryllium Total	0.6	0.59	0.62	0.87	0.78	0.77
Cadmium Total	0.38 J	0.28 J	0.21 J	0.19 J	0.24 J	0.29 J
Calcium Total	5570	4340	3800	4770	6930	5520
Chromium Total	12.4	11	11.3	13.8	11.7	12.4
Cobalt Total	6.5	4.3 J	5.6	8.7	6.8	7.2
Copper Total	21	20.5	12	16	17.1	18.8
Iron Total	20600	20700	15600	17600	17900	19500
Lead Total	20.9	17.7	12.8	13.7	14.9	14.2
Magnesium Total	2310	1880	2290	2560	2170	2110
Manganese Total	597	406	1100	1260	1020	1000
Mercury Total	0.06 U	0.06 U	0.06 U	0.05 U	0.05 J	0.05 U
Molybdenum Total	1.1 J	1.5 J	0.68 J	1.1 J	2.2 J	2 J
Nickel Total	12.1	9.5	11	14.2	13	13.7
Potassium Total	2000	1620	1770	2040	2280	1790
Selenium Total	0.31 U	0.3 U	0.27 U	0.33 U	0.31 U	0.34 U
Silver Total	0.1 U	0.1 U	0.09 U	0.11 U	0.1 U	0.11 U
Sodium Total	260	174	280	279	261	274
Thallium Total	0.12 J	0.11 J	0.12 J	0.15 J	0.12 J	0.13 J
Uranium, Calculated Total	2.45	22	2.89	6.13	5.66	4.03
Vanadium Total	31.1	26.1	27.3	32.6	28.5	28
Zinc Total	51.3	30.9	57	47.1	45.4	56.5

Analytical Results for URS Background Mineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKMIN-13 60930 10/01/00 0 - 0.16	SMBKMIN-14 60931 10/01/00 0 - 0.16	SMBKMIN-15 60932 10/01/00 0 - 0.16	SMBKMIN-16 60933 10/02/00 0 - 0.16	SMBKMIN-17 60934 10/02/00 0 - 0.16	SMBKMIN-18 60935 10/02/00 0 - 0.16
Other Parameters						
Alkalinity, Total, mg/kg	107 J	107 J	89.4 J	97.2 J	165 J	112 J
Bicarbonate Alkalinity, mg/kg	107	107	89.4	97.2	165	112
Carbonate Alkalinity, mg/kg	9 U	9 U	9 U	9 U	9 U	9 U
pH, SU	6.2	6.14	5.81	6.03	6.86	6.58
Total Organic Carbon, mg/kg	66850	52050	42800	55700	66050	61500
Radionuclides, pCi/g						
Lead 210 Total	4 +/- 1.8	11 +/- 2.2	1.9 +/- 1.6 U	2.9 +/- 1.7	3.7 +/- 1.6	1.9 +/- 2.1 U
Polonium 210 Total	3.9 +/- 1.1	12 +/- 2.8	1.9 +/- 0.9	3.4 +/- 1.1	3.8 +/- 1.3	2.5 +/- 0.9
Radium 226, Calculated Total	1.93 +/- 0.12	8.92 +/- 0.51	1.67 +/- 0.11	2.37 +/- 0.15	3.23 +/- 0.19	2.4 +/- 0.15
Radium 228 Total	1.23 +/- 0.092	1.56 +/- 0.12	1.43 +/- 0.1	1.4 +/- 0.1	1.61 +/- 0.11	1.48 +/- 0.11
Thorium 227 Total	0.0858 +/- 0.063	0.536 +/- 0.2	0.0987 +/- 0.083 U	0.124 +/- 0.1 U	0.113 +/- 0.076	0.119 +/- 0.088
Thorium 228 Total	0.947 +/- 0.18	1.2 +/- 0.27	1.45 +/- 0.23	1.11 +/- 0.23	1.6 +/- 0.25	1.15 +/- 0.21
Thorium 230 Total	0.843 +/- 0.14	8.68 +/- 0.64	1.19 +/- 0.18	1.49 +/- 0.22	1.96 +/- 0.25	1.42 +/- 0.2
Thorium 232 Total	0.853 +/- 0.14	1.27 +/- 0.22	1.36 +/- 0.19	1.16 +/- 0.19	1.21 +/- 0.19	1.03 +/- 0.17
Uranium 234 Total	0.836 +/- 0.15	7.99 +/- 0.7	0.943 +/- 0.15	2.48 +/- 0.29	1.91 +/- 0.27	1.47 +/- 0.23
Uranium 235 Total	0.109 +/- 0.057	0.579 +/- 0.16	0.0768 +/- 0.044	0.182 +/- 0.077	0.202 +/- 0.089	0.155 +/- 0.077
Uranium 238 Total	0.807 +/- 0.15	7.3 +/- 0.65	0.959 +/- 0.15	2.03 +/- 0.26	1.87 +/- 0.27	1.33 +/- 0.21

Analytical Results for URS Background Mineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKMIN-19 60936 10/02/00 0 - 0.16	SMBKMIN-20 60937 10/03/00 0 - 0.16	----	----	----	----
Inorganics, mg/kg						
Chloride	3.7	2.58	---- -	---- -	---- -	---- -
Nitrate	0.024 J	---- R	---- -	---- -	---- -	---- -
Nitrite	0.02 U	0.02 U	---- -	---- -	---- -	---- -
Nitrogen, Ammonia	1.96 J	1.69 J	---- -	---- -	---- -	---- -
Phosphate-P	19 J	11.9 J	---- -	---- -	---- -	---- -
Phosphorus	974	779	---- -	---- -	---- -	---- -
Sulfate	5.13	3.32	---- -	---- -	---- -	---- -
Metals, mg/kg						
Aluminum Total	17900	17900	---- -	---- -	---- -	---- -
Antimony Total	0.93 UJ	0.54 UJ	---- -	---- -	---- -	---- -
Arsenic Total	2.4 J	2.4 J	---- -	---- -	---- -	---- -
Barium Total	287	264	---- -	---- -	---- -	---- -
Beryllium Total	0.97	0.95	---- -	---- -	---- -	---- -
Cadmium Total	0.25 J	0.22 J	---- -	---- -	---- -	---- -
Calcium Total	3960	3610	---- -	---- -	---- -	---- -
Chromium Total	6.6	7.3	---- -	---- -	---- -	---- -
Cobalt Total	4.1 J	4.5 J	---- -	---- -	---- -	---- -
Copper Total	9	9.9	---- -	---- -	---- -	---- -
Iron Total	15200	13400	---- -	---- -	---- -	---- -
Lead Total	13.1	13.8	---- -	---- -	---- -	---- -
Magnesium Total	2490	1960	---- -	---- -	---- -	---- -
Manganese Total	1640	1170	---- -	---- -	---- -	---- -
Mercury Total	0.06 U	0.05 U	---- -	---- -	---- -	---- -
Molybdenum Total	0.6 J	0.4 J	---- -	---- -	---- -	---- -
Nickel Total	6.8	8.2	---- -	---- -	---- -	---- -
Potassium Total	2320	1970	---- -	---- -	---- -	---- -
Selenium Total	0.25 U	0.27 U	---- -	---- -	---- -	---- -
Silver Total	0.08 U	0.09 U	---- -	---- -	---- -	---- -
Sodium Total	211	235	---- -	---- -	---- -	---- -
Thallium Total	0.23 J	0.14 J	---- -	---- -	---- -	---- -
Uranium, Calculated Total	5.83	3.67	---- -	---- -	---- -	---- -
Vanadium Total	22.3	23.5	---- -	---- -	---- -	---- -
Zinc Total	62.4	50.5	---- -	---- -	---- -	---- -

Analytical Results for URS Background Mineralized Surface Material Samples

Midnite Mine RI/FS

Location ID:	SMBKMIN-19	SMBKMIN-20	----	----	----	----
Sample ID:	60936	60937				
Sample Date:	10/02/00	10/03/00				
Sample Depth (ft.):	0 - 0.16	0 - 0.16				
Parameter						
Other Parameters						
Alkalinity, Total, mg/kg	141 J	92.7 J	---- -	---- -	---- -	---- -
Bicarbonate Alkalinity, mg/kg	141	92.7	---- -	---- -	---- -	---- -
Carbonate Alkalinity, mg/kg	9 U	9 U	---- -	---- -	---- -	---- -
pH, SU	6.43	6.43	---- -	---- -	---- -	---- -
Total Organic Carbon, mg/kg	54700	42500	---- -	---- -	---- -	---- -
Radionuclides, pCi/g						
Lead 210 Total	3.6 +/- 1.9 U	2.4 +/- 2.3 U	---- -	---- -	---- -	---- -
Polonium 210 Total	3.6 +/- 1.3	1.2 +/- 0.6	---- -	---- -	---- -	---- -
Radium 226, Calculated Total	3.84 +/- 0.23	1.8 +/- 0.11	---- -	---- -	---- -	---- -
Radium 228 Total	3.18 +/- 0.2	2.03 +/- 0.13	---- -	---- -	---- -	---- -
Thorium 227 Total	0.125 +/- 0.079	0.1 +/- 0.068	---- -	---- -	---- -	---- -
Thorium 228 Total	2.07 +/- 0.28	1.62 +/- 0.24	---- -	---- -	---- -	---- -
Thorium 230 Total	2.44 +/- 0.27	1.33 +/- 0.19	---- -	---- -	---- -	---- -
Thorium 232 Total	2.01 +/- 0.24	1.74 +/- 0.22	---- -	---- -	---- -	---- -
Uranium 234 Total	1.9 +/- 0.26	1.1 +/- 0.19	---- -	---- -	---- -	---- -
Uranium 235 Total	0.0559 +/- 0.048	0.145 +/- 0.073	---- -	---- -	---- -	---- -
Uranium 238 Total	1.95 +/- 0.27	1.21 +/- 0.2	---- -	---- -	---- -	---- -

Analytical Results for URS Background Nonmineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKNON-01 60938 10/03/00 0 - 0.16	SMBKNON-02 60939 10/03/00 0 - 0.16	SMBKNON-03 60940 10/02/00 0 - 0.16	SMBKNON-04 60941 10/02/00 0 - 0.16	SMBKNON-05 60942 10/04/00 0 - 0.16	SMBKNON-06 60943 10/04/00 0 - 0.16
Inorganics, mg/kg						
Chloride	2.08	2.53	2.79	2.36	5.68	4.74
Nitrate	0.04 J	0.08 J	0.236	0.374	0.262	0.27
Nitrite	0.02 U	0.02 U	0.02 UJ	0.048 J	0.02 UJ	0.02 UJ
Nitrogen, Ammonia	1.11 J	1.33 J	0.219	0.863	2.52	2.45
Phosphate-P	5.08 J	10.2 J	8.83 J	8.43 J	12.1 J	8.34 J
Phosphorus	319	459	390	352	555	413
Sulfate	2.43	2.55	3.98	3.16	6.09	6.97
Metals, mg/kg						
Aluminum Total	13800	18600	10400	9230	10800	10200
Antimony Total	0.83 UJ	0.96 UJ	0.82 J	0.54 J	0.89 J	0.88 J
Arsenic Total	1.6 J	2.7 J	1 J	0.73 J	1.5 J	2.2 J
Barium Total	142	261	185	155	245	139
Beryllium Total	0.59	0.58	0.42 J	0.44	0.35 J	0.49 J
Cadmium Total	0.22 J	0.22 J	0.23 J	0.23 J	0.3 J	0.2 J
Calcium Total	2590	3630	3310	2840	4130	3130
Chromium Total	7	15.2	6.1	4	5.2	5.7
Cobalt Total	5.1	8.3	4.8 J	4.2 J	4.1 J	4.6 J
Copper Total	6.1	11.9	5.6	4.6	7.1	6.1
Iron Total	16600	19500	11500	10400	9830	11000
Lead Total	13.1	13.8	11.3 J	9 J	12.6 J	10.1 J
Magnesium Total	3080	3140	2490	2680	2030	2420
Manganese Total	869	969	923	932	1170	792
Mercury Total	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.04 U
Molybdenum Total	0.13 J	0.35 J	0.28 U	0.23 U	0.48 U	0.45 U
Nickel Total	5.4	12.6	6	4.6	6	5.1
Potassium Total	2860	2810	2360	2610	1930	2110
Selenium Total	0.26 U	0.3 U	0.31 J	0.23 U	0.31 U	0.29 U
Silver Total	0.09 U	0.1 U	0.09 U	0.08 U	0.1 U	0.1 U
Sodium Total	136	195	115	82.3	154	126
Thallium Total	0.22 J	0.15 J	0.16 J	0.18 J	0.16 J	0.16 J
Uranium, Calculated Total	6.1	3.01	5.4	4.56	4.87	9.21
Vanadium Total	29.5	37	16.6	14.4	13.9	16.7
Zinc Total	55.2	54.4	40.7	42.2	45.9	44.1

Analytical Results for URS Background Nonmineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKNON-01 60938 10/03/00 0 - 0.16	SMBKNON-02 60939 10/03/00 0 - 0.16	SMBKNON-03 60940 10/02/00 0 - 0.16	SMBKNON-04 60941 10/02/00 0 - 0.16	SMBKNON-05 60942 10/04/00 0 - 0.16	SMBKNON-06 60943 10/04/00 0 - 0.16
Other Parameters						
Alkalinity, Total, mg/kg	70.9 J	81.5 J	88.8 J	92.3 J	108 J	80.2 J
Bicarbonate Alkalinity, mg/kg	70.9	81.5	88.8	92.3	108	80.2
Carbonate Alkalinity, mg/kg	9 U	9 U	9 U	9 U	9 U	9 U
pH, SU	5.92	6.47	6.23	6.58	6.17	5.7
Total Organic Carbon, mg/kg	48200	29700	46100	39300	61750	56450
Radionuclides, pCi/g						
Lead 210 Total	4.6 +/- 2.	1.7 +/- 1.7	3.3 +/- 1.7	2.8 +/- 1.7	2.7 +/- 1.8	2.4 +/- 1.8
Polonium 210 Total	4.9 +/- 1.4	2.9 +/- 0.8	2.6 +/- 0.9	4.5 +/- 1.2	3.8 +/- 1.	3.8 +/- 0.9
Radium 226, Calculated Total	2.88 +/- 0.17	1.49 +/- 0.096	1.89 +/- 0.12	2.52 +/- 0.15	2.27 +/- 0.14	2.5 +/- 0.15
Radium 228 Total	3.12 +/- 0.19	1.51 +/- 0.1	2.3 +/- 0.15	3.26 +/- 0.2	2.11 +/- 0.14	2.7 +/- 0.17
Thorium 227 Total	0.127 +/- 0.072	0.105 +/- 0.076	0.188 +/- 0.13	0.108 +/- 0.1 U	0.0578 +/- 0.081 U	0.108 +/- 0.11 U
Thorium 228 Total	2.37 +/- 0.27	1.27 +/- 0.2	2.1 +/- 0.31	2.99 +/- 0.35	1.59 +/- 0.25	1.84 +/- 0.27
Thorium 230 Total	2.09 +/- 0.23	1.2 +/- 0.16	1.38 +/- 0.23	1.47 +/- 0.22	1.71 +/- 0.24	2.84 +/- 0.31
Thorium 232 Total	1.91 +/- 0.22	1.28 +/- 0.17	2.2 +/- 0.3	2.48 +/- 0.3	1.41 +/- 0.21	2 +/- 0.26
Uranium 234 Total	1.67 +/- 0.23	1.24 +/- 0.18	1.6 +/- 0.26	1.38 +/- 0.3	1.7 +/- 0.26	3 +/- 0.36
Uranium 235 Total	0.119 +/- 0.06	0.136 +/- 0.062	0.0871 +/- 0.065	0.127 +/- 0.091	0.0919 +/- 0.064	0.135 +/- 0.075
Uranium 238 Total	2.03 +/- 0.25	0.99 +/- 0.16	1.8 +/- 0.27	1.51 +/- 0.31	1.62 +/- 0.26	3.07 +/- 0.37

Analytical Results for URS Background Nonmineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKNON-07 60944 10/09/00 0 - 0.16	SMBKNON-08 60945 10/09/00 0 - 0.16	SMBKNON-09 60946 10/09/00 0 - 0.16	SMBKNON-10 60947 10/09/00 0 - 0.16	SMBKNON-11 60948 10/09/00 0 - 0.16	SMBKNON-12 60949 10/10/00 0 - 0.16
Inorganics, mg/kg						
Chloride	6.33	6.24	6.25	4.62	5.49	2.01
Nitrate	0.15	3.09	0.643	0.681	0.151	0.343
Nitrite	0.026 J	0.02 UJ	0.02 UJ	0.02 UJ	0.02 UJ	0.054 J
Nitrogen, Ammonia	24.7 J	64.8 J	30.8 J	16.3 J	15.3 J	19 J
Phosphate-P	6.26 J	6.15 J	11.1 J	8.11 J	3.71 J	6.97 J
Phosphorus	480	456	602	363	260	386
Sulfate	13.3	14.1	7.24	8.53	7.71	2.89
Metals, mg/kg						
Aluminum Total	21900	14200	16600	8630	8580	12200
Antimony Total	0.66 UJ	0.63 UJ	1.4 J	0.68 J	0.61 J	0.69 J
Arsenic Total	3.3 J	2.3 J	1.5 J	1.2 J	1.4 J	1.8 J
Barium Total	185	171	262	144	82.1	214
Beryllium Total	1.7	0.86	0.7	0.39 J	0.57	0.45 J
Cadmium Total	0.31 J	0.21 J	0.24 J	0.18 J	0.11 J	0.32 J
Calcium Total	6150	3580	4370	2830	1870	3240
Chromium Total	14	9.4	7.4	4.2	4.8	8.1
Cobalt Total	6.4	7	4.8 J	3.7 J	4.2 J	5.9
Copper Total	17.6	11.2	11.1	5.4	5.3	8.1
Iron Total	19400	14200	13200	8850	9530	12800
Lead Total	15.4 J	11.4 J	11.5 J	8.8 J	7.4 J	11.8 J
Magnesium Total	3910	2820	2500	1860	2120	2530
Manganese Total	705	728	870	651	489	933
Mercury Total	0.12 J	0.09 U	0.08 U	0.05 U	0.13 U	0.08 U
Molybdenum Total	0.67 J	0.6 J	0.62 J	0.4 J	0.32 U	0.46 J
Nickel Total	11.2	8	7.7	4.3 J	4.2 J	8.3
Potassium Total	2770	2160	2150	1750	1760	2180
Selenium Total	0.33 U	0.52 J	0.33 J	0.3 U	0.29 U	0.27 U
Silver Total	0.11 U	0.1 U	0.1 U	0.1 U	0.1 U	0.09 U
Sodium Total	181	162	212	108	129	146
Thallium Total	0.3 J	0.21 J	0.14 J	0.13 J	0.19 J	0.16 J
Uranium, Calculated Total	45.7	16.6	11.5	8.8	13.2	4.24
Vanadium Total	32.3	24.2	19.2	13.4	15.5	20.5
Zinc Total	54.3	45.7	48.5	40.5	28.4	42.3

Analytical Results for URS Background Nonmineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKNON-07 60944 10/09/00 0 - 0.16	SMBKNON-08 60945 10/09/00 0 - 0.16	SMBKNON-09 60946 10/09/00 0 - 0.16	SMBKNON-10 60947 10/09/00 0 - 0.16	SMBKNON-11 60948 10/09/00 0 - 0.16	SMBKNON-12 60949 10/10/00 0 - 0.16
Other Parameters						
Alkalinity, Total, mg/kg	115 J	90.3 J	94.2 J	71.6 J	77.2 J	101 J
Bicarbonate Alkalinity, mg/kg	115	90.3	94.2	71.6	77.2	101
Carbonate Alkalinity, mg/kg	9 U	9 U	9 U	9 U	9 U	9 U
pH, SU	6.33	5.75	6.18	5.75	6.05	6.65
Total Organic Carbon, mg/kg	68800	48450	55000	46200	25050	42000
Radionuclides, pCi/g						
Lead 210 Total	5.5 +/- 2.	3.8 +/- 1.8	4.3 +/- 1.8	3.6 +/- 1.8	2.8 +/- 2.1 U	3 +/- 2.2
Polonium 210 Total	6.1 +/- 1.8	5 +/- 1.1	3.2 +/- 0.9	5.3 +/- 1.3	3.7 +/- 1.1	2.6 +/- 0.7
Radium 226, Calculated Total	3.37 +/- 0.2	3.03 +/- 0.18	2.38 +/- 0.15	2.35 +/- 0.14	2.97 +/- 0.18	1.88 +/- 0.12
Radium 228 Total	3.24 +/- 0.2	2.74 +/- 0.17	2.33 +/- 0.15	2.42 +/- 0.15	3.53 +/- 0.21	1.86 +/- 0.12
Thorium 227 Total	0.219 +/- 0.13	0.183 +/- 0.12	0.185 +/- 0.12	0.29 +/- 0.13	0.102 +/- 0.11 U	0.0486 +/- 0.084 U
Thorium 228 Total	2.89 +/- 0.33	2.37 +/- 0.31	2.02 +/- 0.29	3.7 +/- 0.37	3.57 +/- 0.37	1.85 +/- 0.28
Thorium 230 Total	2.71 +/- 0.3	2.34 +/- 0.29	2.07 +/- 0.27	2.83 +/- 0.31	2.53 +/- 0.28	1.43 +/- 0.22
Thorium 232 Total	2.43 +/- 0.28	1.88 +/- 0.25	2.12 +/- 0.27	3.43 +/- 0.35	3.55 +/- 0.35	1.57 +/- 0.23
Uranium 234 Total	19.5 +/- 1.5	7.39 +/- 0.66	4.63 +/- 0.47	2.88 +/- 0.3	5.32 +/- 0.51	1.21 +/- 0.19
Uranium 235 Total	0.83 +/- 0.19	0.356 +/- 0.12	0.261 +/- 0.099	0.149 +/- 0.065	0.168 +/- 0.078	0.0951 +/- 0.053
Uranium 238 Total	15.2 +/- 1.2	5.53 +/- 0.54	3.83 +/- 0.41	2.93 +/- 0.31	4.39 +/- 0.45	1.41 +/- 0.2

Analytical Results for URS Background Nonmineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKNON-13 60950 10/10/00 0 - 0.16	SMBKNON-14 60951 10/10/00 0 - 0.16	SMBKNON-15 60952 10/10/00 0 - 0.16	SMBKNON-16 60953 10/10/00 0 - 0.16	SMBKNON-17 60954 10/11/00 0 - 0.16	SMBKNON-18 60955 10/11/00 0 - 0.16
Inorganics, mg/kg						
Chloride	6.5	1.67	1.7	4.19	5.34	2.52
Nitrate	0.198	0.476	0.106	0.451	---- R	---- R
Nitrite	0.02 UJ	0.045 J	0.02 UJ	0.087 J	---- R	---- R
Nitrogen, Ammonia	24.7 J	15.6 J	13.3 J	18.9 J	18.8	18.7
Phosphate-P	12.1 J	6.47 J	9.19 J	11 J	12.1 J	7.23 J
Phosphorus	538	347	418	455	508 J	322 J
Sulfate	9.53	2.06	3.2	4.85	4.89	2.99
Metals, mg/kg						
Aluminum Total	10200	10800	10200	14000	11500	11400
Antimony Total	0.65 J	0.79 J	0.55 UJ	0.93 J	0.58 UJ	0.6 UJ
Arsenic Total	1.3 J	1.2 J	1 J	2 J	1.8 U	2 U
Barium Total	226	150	159	220	275	202
Beryllium Total	0.43 J	0.48 J	0.6	0.46 J	0.42 J	0.6
Cadmium Total	0.3 J	0.32 J	0.25 J	0.36 J	0.26 J	0.16 J
Calcium Total	3770	2820	2370	3500	4730	3540
Chromium Total	6	4	3.8	9.6	9.7	7.9
Cobalt Total	5.5	4.3 J	3.9 J	6.6	6.6	5.7
Copper Total	7.4	5.6	5.1	8.6	9.2	8.1
Iron Total	10400	11400	10300	14200	13200	12100
Lead Total	11 J	13.3 J	10.3 J	13.6 J	12.8	15.5
Magnesium Total	1890	2750	2280	2660	2250	2180
Manganese Total	796	1110	843	979	1030	866
Mercury Total	0.05 U	0.12	0.07 J	0.05 U	0.1 U	0.06 U
Molybdenum Total	0.8 J	0.21 J	0.47 J	0.36 J	0.49 J	0.35 J
Nickel Total	6	4.9	4.5	9.3	9.4	7.8
Potassium Total	1820	2670	2240	2450	1890	2040
Selenium Total	0.25 U	0.28 U	0.27 U	0.28 U	0.29 U	0.29 U
Silver Total	0.08 U	0.09 U	0.09 U	0.09 U	0.1 U	0.1 U
Sodium Total	140	121	100	163	198	152
Thallium Total	0.12 J	0.19 J	0.17 J	0.16 J	0.12 J	0.14 J
Uranium, Calculated Total	4.77	9.64	6.71	3.47	2.53	3.43
Vanadium Total	15.5	15.2	14.1	22.8	23.2	20.7
Zinc Total	38	54.7	45.3	43.2	46.7	42.6

Analytical Results for URS Background Nonmineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKNON-13 60950 10/10/00 0 - 0.16	SMBKNON-14 60951 10/10/00 0 - 0.16	SMBKNON-15 60952 10/10/00 0 - 0.16	SMBKNON-16 60953 10/10/00 0 - 0.16	SMBKNON-17 60954 10/11/00 0 - 0.16	SMBKNON-18 60955 10/11/00 0 - 0.16
Other Parameters						
Alkalinity, Total, mg/kg	109 J	72 J	83.8 J	113 J	230 J	188 J
Bicarbonate Alkalinity, mg/kg	109	72	83.8	113	230	188
Carbonate Alkalinity, mg/kg	9 U	9 U	8 U	9 U	9 U	9 U
pH, SU	6.48	6.5	6.63	6.54	6.67	6.48
Total Organic Carbon, mg/kg	51850	58950	42350	39200	45500	51450
Radionuclides, pCi/g						
Lead 210 Total	2.6 +/- 2.1 U	3.7 +/- 2.2	3.1 +/- 2.	2.3 +/- 2. U	1.6 +/- 1.9 U	2.5 +/- 2. U
Polonium 210 Total	4.9 +/- 1.2	4 +/- 0.9	3.9 +/- 0.9	2.8 +/- 1.1	2.7 +/- 0.7	3.7 +/- 0.8
Radium 226, Calculated Total	2.2 +/- 0.13	3 +/- 0.18	3.16 +/- 0.19	1.69 +/- 0.11	1.33 +/- 0.088	1.51 +/- 0.097
Radium 228 Total	2.03 +/- 0.13	3.81 +/- 0.23	3.57 +/- 0.22	1.73 +/- 0.11	1.19 +/- 0.09	1.69 +/- 0.11
Thorium 227 Total	0.0682 +/- 0.1 U	0.228 +/- 0.14	0.275 +/- 0.15	0.127 +/- 0.099	0.0506 +/- 0.097 U	0.156 +/- 0.087
Thorium 228 Total	1.77 +/- 0.27	4.82 +/- 0.46	3.29 +/- 0.38	1.52 +/- 0.25	1.29 +/- 0.22	1.68 +/- 0.22
Thorium 230 Total	1.26 +/- 0.2	3.55 +/- 0.37	2.6 +/- 0.32	1.3 +/- 0.21	1.02 +/- 0.17	1.14 +/- 0.15
Thorium 232 Total	1.79 +/- 0.25	4.98 +/- 0.45	3.04 +/- 0.35	1.42 +/- 0.22	1.09 +/- 0.17	1.55 +/- 0.18
Uranium 234 Total	1.91 +/- 0.23	2.99 +/- 0.35	2.25 +/- 0.29	1.21 +/- 0.19	0.808 +/- 0.13	1.19 +/- 0.21
Uranium 235 Total	0.14 +/- 0.061	0.113 +/- 0.065	0.155 +/- 0.076	0.0969 +/- 0.055	0.128 +/- 0.055	0.0644 +/- 0.049
Uranium 238 Total	1.58 +/- 0.21	3.22 +/- 0.36	2.23 +/- 0.29	1.15 +/- 0.18	0.829 +/- 0.14	1.14 +/- 0.2

Analytical Results for URS Background Nonmineralized Surface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SMBKNON-19 60956 10/11/00 0 - 0.16	SMBKNON-20 60957 10/11/00 0 - 0.16	----	----	----	----
Inorganics, mg/kg						
Chloride	3.32	2.61	---- -	---- -	---- -	---- -
Nitrate	---- R	---- R	---- -	---- -	---- -	---- -
Nitrite	---- R	---- R	---- -	---- -	---- -	---- -
Nitrogen, Ammonia	14.9	8.65	---- -	---- -	---- -	---- -
Phosphate-P	9.02 J	10 J	---- -	---- -	---- -	---- -
Phosphorus	295 J	317 J	---- -	---- -	---- -	---- -
Sulfate	4.82	2.11	---- -	---- -	---- -	---- -
Metals, mg/kg						
Aluminum Total	10000	11400	---- -	---- -	---- -	---- -
Antimony Total	0.58 UJ	0.68 J	---- -	---- -	---- -	---- -
Arsenic Total	0.98 U	1.7 U	---- -	---- -	---- -	---- -
Barium Total	161	172	---- -	---- -	---- -	---- -
Beryllium Total	0.77	0.83	---- -	---- -	---- -	---- -
Cadmium Total	0.09 J	0.17 J	---- -	---- -	---- -	---- -
Calcium Total	2500	2490	---- -	---- -	---- -	---- -
Chromium Total	3.6	6.9	---- -	---- -	---- -	---- -
Cobalt Total	3.3 J	5.1	---- -	---- -	---- -	---- -
Copper Total	6.2	6.8	---- -	---- -	---- -	---- -
Iron Total	8600	14200	---- -	---- -	---- -	---- -
Lead Total	8.8	11.3	---- -	---- -	---- -	---- -
Magnesium Total	1660	2190	---- -	---- -	---- -	---- -
Manganese Total	638	941	---- -	---- -	---- -	---- -
Mercury Total	0.1 U	0.04 U	---- -	---- -	---- -	---- -
Molybdenum Total	0.56 J	0.56 J	---- -	---- -	---- -	---- -
Nickel Total	3.7 J	6.3	---- -	---- -	---- -	---- -
Potassium Total	1710	2280	---- -	---- -	---- -	---- -
Selenium Total	0.28 U	0.28 U	---- -	---- -	---- -	---- -
Silver Total	0.09 U	0.09 U	---- -	---- -	---- -	---- -
Sodium Total	194	125	---- -	---- -	---- -	---- -
Thallium Total	0.16 J	0.19 J	---- -	---- -	---- -	---- -
Uranium, Calculated Total	7.91	5.23	---- -	---- -	---- -	---- -
Vanadium Total	13.2	23.1	---- -	---- -	---- -	---- -
Zinc Total	28.1	40	---- -	---- -	---- -	---- -

Analytical Results for URS Background Nonmineralized Surface Material Samples

Midnite Mine RI/FS

Location ID:	SMBKNON-19	SMBKNON-20	----	----	----	----
Sample ID:	60956	60957				
Sample Date:	10/11/00	10/11/00				
Sample Depth (ft.):	0 - 0.16	0 - 0.16				
Parameter						
Other Parameters						
Alkalinity, Total, mg/kg	171 J	148 J	---- -	---- -	---- -	---- -
Bicarbonate Alkalinity, mg/kg	171	148	---- -	---- -	---- -	---- -
Carbonate Alkalinity, mg/kg	9 U	9 U	---- -	---- -	---- -	---- -
pH, SU	6.14	6.37	---- -	---- -	---- -	---- -
Total Organic Carbon, mg/kg	48000	34300	---- -	---- -	---- -	---- -
Radionuclides, pCi/g						
Lead 210 Total	3.1 +/- 2.1	3.3 +/- 2.1	---- -	---- -	---- -	---- -
Polonium 210 Total	3.1 +/- 0.7	3.4 +/- 0.8	---- -	---- -	---- -	---- -
Radium 226, Calculated Total	2.97 +/- 0.18	2.11 +/- 0.13	---- -	---- -	---- -	---- -
Radium 228 Total	2.19 +/- 0.14	2.53 +/- 0.16	---- -	---- -	---- -	---- -
Thorium 227 Total	0.285 +/- 0.12	0.157 +/- 0.088 U	---- -	---- -	---- -	---- -
Thorium 228 Total	1.64 +/- 0.23	2.27 +/- 0.27	---- -	---- -	---- -	---- -
Thorium 230 Total	2.04 +/- 0.23	1.9 +/- 0.22	---- -	---- -	---- -	---- -
Thorium 232 Total	1.65 +/- 0.2	2.5 +/- 0.26	---- -	---- -	---- -	---- -
Uranium 234 Total	2.57 +/- 0.33	1.73 +/- 0.24	---- -	---- -	---- -	---- -
Uranium 235 Total	0.227 +/- 0.097	0.168 +/- 0.076	---- -	---- -	---- -	---- -
Uranium 238 Total	2.62 +/- 0.33	1.73 +/- 0.24	---- -	---- -	---- -	---- -

Analytical Results for URS Background Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKMIN-01 61000 09/28/00 0.16 - 0.5	SSBKMIN-02 61001 09/28/00 0.16 - 0.5	SSBKMIN-03 61002 09/28/00 0.16 - 0.5	SSBKMIN-04 61003 09/28/00 0.16 - 0.5	SSBKMIN-05 61004 09/29/00 0.16 - 0.5	SSBKMIN-06 61005 09/29/00 0.16 - 0.5
Inorganics, mg/kg						
SEM Phosphorus	25.5	---- -	---- -	8.5 J	---- -	18.1 J
Metals, meq/100g						
EM Calcium	12.4	---- -	---- -	16.5	---- -	16.4
EM Magnesium	1.53	---- -	---- -	2.05	---- -	2.39
EM Potassium	1.09	---- -	---- -	1	---- -	1.08
EM Sodium	0.025	---- -	---- -	0.043	---- -	0.037
Metals, mg/kg						
Aluminum Total	---- -	16500 J	---- -	13500 J	13900 J	---- -
SEM Aluminum	4.7	---- -	---- -	2.2 J	---- -	3.6 J
Antimony Total	---- -	1.2 J	---- -	0.84 J	1 J	---- -
SEM Antimony	0.1 U	---- -	---- -	0.11 U	---- -	0.11 U
Arsenic Total	---- -	37.8 J	---- -	67.2 J	36.6 J	---- -
SEM Arsenic	0.36 J	---- -	---- -	0.35 J	---- -	0.22 J
Barium Total	---- -	315 J	---- -	242 J	301 J	---- -
SEM Barium	2.3 J	---- -	---- -	2.6 J	---- -	2.3 J
Beryllium Total	---- -	0.64 J	---- -	0.79 J	0.54 J	---- -
SEM Beryllium	0.002 U	---- -	---- -	0.002 U	---- -	0.002 U
Cadmium Total	---- -	0.28 UJ	---- -	0.29 UJ	0.2 UJ	---- -
SEM Cadmium	0.08	---- -	---- -	0.06 J	---- -	0.1
Calcium Total	---- -	4130 J	---- -	4330 J	3350 J	---- -
SEM Calcium	245	---- -	---- -	296	---- -	248
Chromium Total	---- -	8.5 J	---- -	14.9 J	8.7 J	---- -
SEM Chromium	0.02 J	---- -	---- -	0.02 U	---- -	0.03 J
Cobalt Total	---- -	8.1 J	---- -	21.3 J	17.4 J	---- -
SEM Cobalt	0.14 J	---- -	---- -	0.26 J	---- -	0.28 J
Copper Total	---- -	24.3 J	---- -	35.8 J	18.9 J	---- -
SEM Copper	3.2	---- -	---- -	5.1	---- -	3.7
Iron Total	---- -	21500 J	---- -	28500 J	19800 J	---- -
SEM Iron	156	---- -	---- -	83.5	---- -	154
Lead Total	---- -	10.5 J	---- -	10.7 J	9.1 J	---- -
SEM Lead	0.96	---- -	---- -	0.74	---- -	1.1
Magnesium Total	---- -	1600 J	---- -	1880 J	1670 J	---- -
SEM Magnesium	36.2	---- -	---- -	57	---- -	62.5
Manganese Total	---- -	690 J	---- -	749 J	727 J	---- -

Analytical Results for URS Background Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: Sample ID: Sample Date: Sample Depth (ft.): **Parameter**	SSBKMIN-01 61000 09/28/00 0.16 - 0.5	SSBKMIN-02 61001 09/28/00 0.16 - 0.5	SSBKMIN-03 61002 09/28/00 0.16 - 0.5	SSBKMIN-04 61003 09/28/00 0.16 - 0.5	SSBKMIN-05 61004 09/29/00 0.16 - 0.5	SSBKMIN-06 61005 09/29/00 0.16 - 0.5
Metals, mg/kg						
SEM Manganese	22.5	---- -	---- -	16.9	---- -	34.1
SEM Mercury	---- R	---- -	---- -	---- R	---- -	---- R
Molybdenum Total	---- -	1.4 J	---- -	2 J	1.1 J	---- -
SEM Molybdenum	0.04 J	---- -	---- -	0.06 J	---- -	0.09 J
Nickel Total	---- -	14.4 J	---- -	15.1 J	11.1 J	---- -
SEM Nickel	0.9	---- -	---- -	0.76 J	---- -	1.3
Potassium Total	---- -	1330 J	---- -	1730 J	1440 J	---- -
SEM Potassium	308	---- -	---- -	316	---- -	336
Selenium Total	---- -	0.41 UJ	---- -	0.56 J	0.4 J	---- -
SEM Selenium	0.07 J	---- -	---- -	0.1	---- -	0.06 J
Silver Total	---- -	0.16 UJ	---- -	0.15 UJ	0.14 UJ	---- -
SEM Silver	0.02 U	---- -	---- -	0.02 U	---- -	0.02 U
Sodium Total	---- -	221 J	---- -	88.2 J	145 J	---- -
SEM Sodium	4.2 U	---- -	---- -	3.4 U	---- -	4.6 U
Thallium Total	---- -	0.11 J	---- -	0.2 J	0.12 J	---- -
SEM Thallium	0.11 U	---- -	---- -	0.12 U	---- -	0.11 U
SEM Uranium	0.38	---- -	---- -	0.5	---- -	0.37
Uranium, Calculated Total	---- -	2.52	---- -	4.67	2.89	---- -
Vanadium Total	---- -	20.3 J	---- -	32.1 J	21.7 J	---- -
SEM Vanadium	0.19 J	---- -	---- -	0.07 J	---- -	0.14 J
Zinc Total	---- -	43.5 J	---- -	33.3 J	30.6 J	---- -
SEM Zinc	2.2	---- -	---- -	1.4	---- -	3.7
Other Parameters						
Cation Exchange Capacity, meq/g	0.31	---- -	---- -	0.318	---- -	0.366
Moisture Content, %	8.3	11.67	7.24	8.55	8.59	10.5
pH, SU	6.6	6.82	6.9	6.77	6.23	6.51
Total Organic Carbon, mg/kg	31900	35800	23100	39050	27650	51300
Radionuclides, pCi/g						
Lead 210 Total	---- -	1.9 +/- 1.4 UJ	---- -	2.6 +/- 1.8 UJ	1.6 +/- 1.1 UJ	---- -
Polonium 210 Total	---- -	0.0394 +/- 3.659 UJ	---- -	-0.367 +/- 4.616 UJ	0.727 +/- 2.982 UJ	---- -
Radium 226, Calculated Total	---- -	1.89 +/- 0.12	---- -	2.2 +/- 0.13	1.97 +/- 0.12	---- -
Radium 228 Total	---- -	1.27 +/- 0.092	---- -	1.84 +/- 0.12	1.43 +/- 0.1	---- -
Thorium 227 Total	---- -	0.157 +/- 0.11	---- -	0.168 +/- 0.11	0.267 +/- 0.12	---- -
Thorium 228 Total	---- -	1.16 +/- 0.21	---- -	1.61 +/- 0.25	1.47 +/- 0.22	---- -

Analytical Results for URS Background Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: Sample ID: Sample Date: Sample Depth (ft.): **Parameter**	SSBKMIN-01 61000 09/28/00 0.16 - 0.5	SSBKMIN-02 61001 09/28/00 0.16 - 0.5	SSBKMIN-03 61002 09/28/00 0.16 - 0.5	SSBKMIN-04 61003 09/28/00 0.16 - 0.5	SSBKMIN-05 61004 09/29/00 0.16 - 0.5	SSBKMIN-06 61005 09/29/00 0.16 - 0.5
Radionuclides, pCi/g						
Thorium 230 Total	---- -	1.08 +/- 0.19	---- -	1.63 +/- 0.23	1.09 +/- 0.17	---- -
Thorium 232 Total	---- -	1.19 +/- 0.2	---- -	1.56 +/- 0.23	1.08 +/- 0.17	---- -
Uranium 234 Total	---- -	0.888 +/- 0.17	---- -	1.53 +/- 0.19	1.22 +/- 0.17	---- -
Uranium 235 Total	---- -	0.0761 +/- 0.053	---- -	0.125 +/- 0.056	0.116 +/- 0.054	---- -
Uranium 238 Total	---- -	0.834 +/- 0.17	---- -	1.55 +/- 0.2	0.951 +/- 0.15	---- -

Analytical Results for URS Background Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKMIN-07 61006 09/29/00 0.16 - 0.5	SSBKMIN-08 61007 09/29/00 0.16 - 0.5	SSBKMIN-09 61008 09/29/00 0.16 - 0.5	SSBKMIN-10 61009 09/30/00 0.16 - 0.66	SSBKMIN-11 61010 09/30/00 0.16 - 0.66	SSBKMIN-12 61011 10/01/00 0.16 - 0.5
Inorganics, mg/kg						
SEM Phosphorus	---- -	---- -	---- -	---- -	14.6 J	---- -
Metals, meq/100g						
EM Calcium	---- -	---- -	---- -	---- -	13.3	---- -
EM Magnesium	---- -	---- -	---- -	---- -	1.59	---- -
EM Potassium	---- -	---- -	---- -	---- -	1.12	---- -
EM Sodium	---- -	---- -	---- -	---- -	0.035	---- -
Metals, mg/kg						
Aluminum Total	---- -	---- -	---- -	12200 J	---- -	---- -
SEM Aluminum	---- -	---- -	---- -	---- -	2.8 J	---- -
Antimony Total	---- -	---- -	---- -	0.86 J	---- -	---- -
SEM Antimony	---- -	---- -	---- -	---- -	0.11 U	---- -
Arsenic Total	---- -	---- -	---- -	86.1 J	---- -	---- -
SEM Arsenic	---- -	---- -	---- -	---- -	0.95	---- -
Barium Total	---- -	---- -	---- -	239 J	---- -	---- -
SEM Barium	---- -	---- -	---- -	---- -	2.2 J	---- -
Beryllium Total	---- -	---- -	---- -	0.6 J	---- -	---- -
SEM Beryllium	---- -	---- -	---- -	---- -	0.002 U	---- -
Cadmium Total	---- -	---- -	---- -	0.32 UJ	---- -	---- -
SEM Cadmium	---- -	---- -	---- -	---- -	0.05 J	---- -
Calcium Total	---- -	---- -	---- -	4400 J	---- -	---- -
SEM Calcium	---- -	---- -	---- -	---- -	231	---- -
Chromium Total	---- -	---- -	---- -	12.1 J	---- -	---- -
SEM Chromium	---- -	---- -	---- -	---- -	0.02 U	---- -
Cobalt Total	---- -	---- -	---- -	8.4 J	---- -	---- -
SEM Cobalt	---- -	---- -	---- -	---- -	0.18 J	---- -
Copper Total	---- -	---- -	---- -	33.1 J	---- -	---- -
SEM Copper	---- -	---- -	---- -	---- -	3	---- -
Iron Total	---- -	---- -	---- -	28600 J	---- -	---- -
SEM Iron	---- -	---- -	---- -	---- -	111	---- -
Lead Total	---- -	---- -	---- -	9.6 J	---- -	---- -
SEM Lead	---- -	---- -	---- -	---- -	1	---- -
Magnesium Total	---- -	---- -	---- -	1710 J	---- -	---- -
SEM Magnesium	---- -	---- -	---- -	---- -	45.8	---- -
Manganese Total	---- -	---- -	---- -	620 J	---- -	---- -

Analytical Results for URS Background Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKMIN-07 61006 09/29/00 0.16 - 0.5	SSBKMIN-08 61007 09/29/00 0.16 - 0.5	SSBKMIN-09 61008 09/29/00 0.16 - 0.5	SSBKMIN-10 61009 09/30/00 0.16 - 0.66	SSBKMIN-11 61010 09/30/00 0.16 - 0.66	SSBKMIN-12 61011 10/01/00 0.16 - 0.5
Metals, mg/kg						
SEM Manganese	---- -	---- -	---- -	---- -	15.9	---- -
SEM Mercury	---- -	---- -	---- -	---- -	---- R	---- -
Molybdenum Total	---- -	---- -	---- -	2.4 J	---- -	---- -
SEM Molybdenum	---- -	---- -	---- -	---- -	0.05 J	---- -
Nickel Total	---- -	---- -	---- -	12.6 J	---- -	---- -
SEM Nickel	---- -	---- -	---- -	---- -	0.5 J	---- -
Potassium Total	---- -	---- -	---- -	1630 J	---- -	---- -
SEM Potassium	---- -	---- -	---- -	---- -	352	---- -
Selenium Total	---- -	---- -	---- -	0.39 J	---- -	---- -
SEM Selenium	---- -	---- -	---- -	---- -	0.05 U	---- -
Silver Total	---- -	---- -	---- -	0.15 UJ	---- -	---- -
SEM Silver	---- -	---- -	---- -	---- -	0.02 U	---- -
Sodium Total	---- -	---- -	---- -	85.7 J	---- -	---- -
SEM Sodium	---- -	---- -	---- -	---- -	2.6 U	---- -
Thallium Total	---- -	---- -	---- -	0.11 J	---- -	---- -
SEM Thallium	---- -	---- -	---- -	---- -	0.11 U	---- -
SEM Uranium	---- -	---- -	---- -	---- -	0.78	---- -
Uranium, Calculated Total	---- -	---- -	---- -	3.36	---- -	---- -
Vanadium Total	---- -	---- -	---- -	34.9 J	---- -	---- -
SEM Vanadium	---- -	---- -	---- -	---- -	0.09 J	---- -
Zinc Total	---- -	---- -	---- -	26.6 J	---- -	---- -
SEM Zinc	---- -	---- -	---- -	---- -	1	---- -
Other Parameters						
Cation Exchange Capacity, meq/g	---- -	---- -	---- -	---- -	0.274	---- -
Moisture Content, %	10.29	10.37	7.12	11.02	10.78	7.69
pH, SU	6.35	6.11	6.68	6.8	7.18	6.47
Total Organic Carbon, mg/kg	45150	39450	24600	37900	31550	24550
Radionuclides, pCi/g						
Lead 210 Total	---- -	---- -	---- -	2.9 +/- 1.4 UJ	---- -	---- -
Polonium 210 Total	---- -	---- -	---- -	1.153 +/- 3.899 UJ	---- -	---- -
Radium 226, Calculated Total	---- -	---- -	---- -	2.11 +/- 0.13	---- -	---- -
Radium 228 Total	---- -	---- -	---- -	1.67 +/- 0.11	---- -	---- -
Thorium 227 Total	---- -	---- -	---- -	0.182 +/- 0.12	---- -	---- -
Thorium 228 Total	---- -	---- -	---- -	1.27 +/- 0.22	---- -	---- -

Analytical Results for URS Background Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKMIN-07 61006 09/29/00 0.16 - 0.5	SSBKMIN-08 61007 09/29/00 0.16 - 0.5	SSBKMIN-09 61008 09/29/00 0.16 - 0.5	SSBKMIN-10 61009 09/30/00 0.16 - 0.66	SSBKMIN-11 61010 09/30/00 0.16 - 0.66	SSBKMIN-12 61011 10/01/00 0.16 - 0.5
Radionuclides, pCi/g						
Thorium 230 Total	---- -	---- -	---- -	1.03 +/- 0.18	---- -	---- -
Thorium 232 Total	---- -	---- -	---- -	1.38 +/- 0.21	---- -	---- -
Uranium 234 Total	---- -	---- -	---- -	1.37 +/- 0.19	---- -	---- -
Uranium 235 Total	---- -	---- -	---- -	0.112 +/- 0.056	---- -	---- -
Uranium 238 Total	---- -	---- -	---- -	1.11 +/- 0.17	---- -	---- -

Analytical Results for URS Background Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKMIN-13 61012 10/01/00 0.16 - 0.5	SSBKMIN-14 61013 10/01/00 0.16 - 0.5	SSBKMIN-15 61014 10/01/00 0.16 - 0.5	SSBKMIN-16 61015 10/02/00 0.16 - 0.66	SSBKMIN-17 61016 10/02/00 0.16 - 0.66	SSBKMIN-18 61017 10/02/00 0.16 - 0.66
Inorganics, mg/kg						
SEM Phosphorus	---- -	---- -	---- -	13.3 J	---- -	---- -
Metals, meq/100g						
EM Calcium	---- -	---- -	---- -	9.93	---- -	---- -
EM Magnesium	---- -	---- -	---- -	1.77	---- -	---- -
EM Potassium	---- -	---- -	---- -	0.492	---- -	---- -
EM Sodium	---- -	---- -	---- -	0.061	---- -	---- -
Metals, mg/kg						
Aluminum Total	14500 J	---- -	15100 J	---- -	14800 J	---- -
SEM Aluminum	---- -	---- -	---- -	1.7 J	---- -	---- -
Antimony Total	1.1 J	---- -	1 J	---- -	1 J	---- -
SEM Antimony	---- -	---- -	---- -	0.11 U	---- -	---- -
Arsenic Total	69.4 J	---- -	3 J	---- -	19.8 J	---- -
SEM Arsenic	---- -	---- -	---- -	0.14 J	---- -	---- -
Barium Total	258 J	---- -	349 J	---- -	324 J	---- -
SEM Barium	---- -	---- -	---- -	3.7 J	---- -	---- -
Beryllium Total	0.39 J	---- -	0.47 J	---- -	0.63 J	---- -
SEM Beryllium	---- -	---- -	---- -	0.002 J	---- -	---- -
Cadmium Total	0.14 UJ	---- -	0.11 UJ	---- -	0.22 UJ	---- -
SEM Cadmium	---- -	---- -	---- -	0.05 J	---- -	---- -
Calcium Total	2840 J	---- -	2280 J	---- -	4280 J	---- -
SEM Calcium	---- -	---- -	---- -	255	---- -	---- -
Chromium Total	8.1 J	---- -	7.8 J	---- -	8.8 J	---- -
SEM Chromium	---- -	---- -	---- -	0.03 J	---- -	---- -
Cobalt Total	5 J	---- -	5.3 J	---- -	7 J	---- -
SEM Cobalt	---- -	---- -	---- -	0.09 J	---- -	---- -
Copper Total	17.3 J	---- -	10.2 J	---- -	15.6 J	---- -
SEM Copper	---- -	---- -	---- -	2.4	---- -	---- -
Iron Total	17100 J	---- -	13200 J	---- -	16400 J	---- -
SEM Iron	---- -	---- -	---- -	132	---- -	---- -
Lead Total	9.7 J	---- -	10.2 J	---- -	11.5 J	---- -
SEM Lead	---- -	---- -	---- -	0.94	---- -	---- -
Magnesium Total	1770 J	---- -	1980 J	---- -	1900 J	---- -
SEM Magnesium	---- -	---- -	---- -	63.8	---- -	---- -
Manganese Total	379 J	---- -	903 J	---- -	995 J	---- -

Analytical Results for URS Background Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKMIN-13 61012 10/01/00 0.16 - 0.5	SSBKMIN-14 61013 10/01/00 0.16 - 0.5	SSBKMIN-15 61014 10/01/00 0.16 - 0.5	SSBKMIN-16 61015 10/02/00 0.16 - 0.66	SSBKMIN-17 61016 10/02/00 0.16 - 0.66	SSBKMIN-18 61017 10/02/00 0.16 - 0.66
Metals, mg/kg						
SEM Manganese	---- -	---- -	---- -	25.3	---- -	---- -
SEM Mercury	---- -	---- -	---- -	---- R	---- -	---- -
Molybdenum Total	0.89 J	---- -	0.52 UJ	---- -	1.7 J	---- -
SEM Molybdenum	---- -	---- -	---- -	0.04 J	---- -	---- -
Nickel Total	8.4 J	---- -	8.8 J	---- -	11.6 J	---- -
SEM Nickel	---- -	---- -	---- -	1.2	---- -	---- -
Potassium Total	1340 J	---- -	1340 J	---- -	1850 J	---- -
SEM Potassium	---- -	---- -	---- -	142	---- -	---- -
Selenium Total	0.44 UJ	---- -	0.46 UJ	---- -	0.39 UJ	---- -
SEM Selenium	---- -	---- -	---- -	0.05 U	---- -	---- -
Silver Total	0.17 UJ	---- -	0.18 UJ	---- -	0.15 UJ	---- -
SEM Silver	---- -	---- -	---- -	0.02 U	---- -	---- -
Sodium Total	103 J	---- -	125 J	---- -	120 J	---- -
SEM Sodium	---- -	---- -	---- -	10.1	---- -	---- -
Thallium Total	0.1 J	---- -	0.11 J	---- -	0.11 J	---- -
SEM Thallium	---- -	---- -	---- -	0.12 U	---- -	---- -
SEM Uranium	---- -	---- -	---- -	2.8	---- -	---- -
Uranium, Calculated Total	2.79	---- -	2.99	---- -	4.85	---- -
Vanadium Total	21.7 J	---- -	18.3 J	---- -	22.3 J	---- -
SEM Vanadium	---- -	---- -	---- -	0.13 J	---- -	---- -
Zinc Total	29.7 J	---- -	41.2 J	---- -	35 J	---- -
SEM Zinc	---- -	---- -	---- -	1.7	---- -	---- -
Other Parameters						
Cation Exchange Capacity, meq/g	---- -	---- -	---- -	0.218	---- -	---- -
Moisture Content, %	10.89	10.4	12.03	12.36	14.27	16.1
pH, SU	6.25	6.23	6.26	6.23	6.77	6.49
Total Organic Carbon, mg/kg	27850	21750	16100	26850	37700	32600
Radionuclides, pCi/g						
Lead 210 Total	2.1 +/- 1.4 UJ	---- -	1.2 +/- 1. UJ	---- -	1.9 +/- 1.3 UJ	---- -
Polonium 210 Total	0.811 +/- 3.673 UJ	---- -	1.773 +/- 2.844 UJ	---- -	3.429 +/- 3.69 UJ	---- -
Radium 226, Calculated Total	1.66 +/- 0.1	---- -	1.56 +/- 0.099	---- -	3 +/- 0.18	---- -
Radium 228 Total	1.35 +/- 0.094	---- -	1.58 +/- 0.11	---- -	1.7 +/- 0.12	---- -
Thorium 227 Total	0.109 +/- 0.082	---- -	0.16 +/- 0.099	---- -	0.213 +/- 0.1	---- -
Thorium 228 Total	1.36 +/- 0.21	---- -	1.51 +/- 0.23	---- -	1.32 +/- 0.2	---- -

Analytical Results for URS Background Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: Sample ID: Sample Date: Sample Depth (ft.): **Parameter**	SSBKMIN-13 61012 10/01/00 0.16 - 0.5	SSBKMIN-14 61013 10/01/00 0.16 - 0.5	SSBKMIN-15 61014 10/01/00 0.16 - 0.5	SSBKMIN-16 61015 10/02/00 0.16 - 0.66	SSBKMIN-17 61016 10/02/00 0.16 - 0.66	SSBKMIN-18 61017 10/02/00 0.16 - 0.66
Radionuclides, pCi/g						
Thorium 230 Total	0.919 +/- 0.16	---- -	0.943 +/- 0.16	---- -	2.04 +/- 0.23	---- -
Thorium 232 Total	1.08 +/- 0.17	---- -	1.43 +/- 0.21	---- -	1.21 +/- 0.17	---- -
Uranium 234 Total	0.876 +/- 0.15	---- -	1.14 +/- 0.17	---- -	1.75 +/- 0.22	---- -
Uranium 235 Total	0.0991 +/- 0.053	---- -	0.0959 +/- 0.053	---- -	0.129 +/- 0.06	---- -
Uranium 238 Total	0.921 +/- 0.15	---- -	0.989 +/- 0.16	---- -	1.61 +/- 0.21	---- -

Analytical Results for URS Background Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKMIN-19 61018 10/02/00 0.16 - 0.66	SSBKMIN-20 61019 10/03/00 0.16 - 0.66	----	----	----	----
Metals, mg/kg						
Aluminum Total	12900 J	---- -	---- -	---- -	---- -	---- -
Antimony Total	1.1 J	---- -	---- -	---- -	---- -	---- -
Arsenic Total	2.3 J	---- -	---- -	---- -	---- -	---- -
Barium Total	291 J	---- -	---- -	---- -	---- -	---- -
Beryllium Total	0.72 J	---- -	---- -	---- -	---- -	---- -
Cadmium Total	0.18 UJ	---- -	---- -	---- -	---- -	---- -
Calcium Total	2710 J	---- -	---- -	---- -	---- -	---- -
Chromium Total	4 J	---- -	---- -	---- -	---- -	---- -
Cobalt Total	3.6 J	---- -	---- -	---- -	---- -	---- -
Copper Total	7.9 J	---- -	---- -	---- -	---- -	---- -
Iron Total	11600 J	---- -	---- -	---- -	---- -	---- -
Lead Total	10.4 J	---- -	---- -	---- -	---- -	---- -
Magnesium Total	2150 J	---- -	---- -	---- -	---- -	---- -
Manganese Total	1300 J	---- -	---- -	---- -	---- -	---- -
Molybdenum Total	0.62 J	---- -	---- -	---- -	---- -	---- -
Nickel Total	5.5 J	---- -	---- -	---- -	---- -	---- -
Potassium Total	1900 J	---- -	---- -	---- -	---- -	---- -
Selenium Total	0.44 UJ	---- -	---- -	---- -	---- -	---- -
Silver Total	0.17 UJ	---- -	---- -	---- -	---- -	---- -
Sodium Total	108 J	---- -	---- -	---- -	---- -	---- -
Thallium Total	0.14 J	---- -	---- -	---- -	---- -	---- -
Uranium, Calculated Total	6.78	---- -	---- -	---- -	---- -	---- -
Vanadium Total	13.3 J	---- -	---- -	---- -	---- -	---- -
Zinc Total	44.4 J	---- -	---- -	---- -	---- -	---- -
Other Parameters						
Moisture Content, %	11.42	7.65	---- -	---- -	---- -	---- -
pH, SU	6.6	6.56	---- -	---- -	---- -	---- -
Total Organic Carbon, mg/kg	28050	25150	---- -	---- -	---- -	---- -
Radionuclides, pCi/g						
Lead 210 Total	4.4 +/- 1.4 J	---- -	---- -	---- -	---- -	---- -
Polonium 210 Total	3.685 +/- 4.67 UJ	---- -	---- -	---- -	---- -	---- -
Radium 226, Calculated Total	3.87 +/- 0.23	---- -	---- -	---- -	---- -	---- -
Radium 228 Total	3.23 +/- 0.2	---- -	---- -	---- -	---- -	---- -
Thorium 227 Total	0.184 +/- 0.097	---- -	---- -	---- -	---- -	---- -

Analytical Results for URS Background Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKMIN-19 61018 10/02/00 0.16 - 0.66	SSBKMIN-20 61019 10/03/00 0.16 - 0.66	----	----	----	----
Radionuclides, pCi/g						
Thorium 228 Total	2.95 +/- 0.31	---- -	---- -	---- -	---- -	---- -
Thorium 230 Total	2.94 +/- 0.29	---- -	---- -	---- -	---- -	---- -
Thorium 232 Total	2.51 +/- 0.27	---- -	---- -	---- -	---- -	---- -
Uranium 234 Total	2.26 +/- 0.26	---- -	---- -	---- -	---- -	---- -
Uranium 235 Total	0.116 +/- 0.057	---- -	---- -	---- -	---- -	---- -
Uranium 238 Total	2.26 +/- 0.26	---- -	---- -	---- -	---- -	---- -

Analytical Results for URS Background Non-Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKNON-01 61020 10/03/00 0.16 - 0.66	SSBKNON-02 61021 10/03/00 0.16 - 0.66	SSBKNON-03 61022 10/03/00 0.16 - 0.66	SSBKNON-04 61023 10/03/00 0.16 - 0.66	SSBKNON-05 61024 10/04/00 0.16 - 0.66	SSBKNON-06 61025 10/04/00 0.16 - 0.66
Inorganics, mg/kg						
SEM Phosphorus	19.1	---- -	---- -	---- -	---- -	19.2 J
Metals, meq/100g						
EM Calcium	8.46	---- -	---- -	---- -	---- -	6.32
EM Magnesium	1.42	---- -	---- -	---- -	---- -	1.1
EM Potassium	0.665	---- -	---- -	---- -	---- -	0.357
EM Sodium	0.024	---- -	---- -	---- -	---- -	0.027
Metals, mg/kg						
Aluminum Total	---- -	11800 J	---- -	7720 J	---- -	---- -
SEM Aluminum	1.1 J	---- -	---- -	---- -	---- -	1.8 J
Antimony Total	---- -	1 J	---- -	0.99 J	---- -	---- -
SEM Antimony	0.1 U	---- -	---- -	---- -	---- -	0.11 U
Arsenic Total	---- -	1.8 J	---- -	0.78 J	---- -	---- -
SEM Arsenic	0.07 U	---- -	---- -	---- -	---- -	0.09 U
Barium Total	---- -	230 J	---- -	168 J	---- -	---- -
SEM Barium	3 J	---- -	---- -	---- -	---- -	2.5 J
Beryllium Total	---- -	0.37 J	---- -	0.31 J	---- -	---- -
SEM Beryllium	0.002 U	---- -	---- -	---- -	---- -	0.002 U
Cadmium Total	---- -	0.17 UJ	---- -	0.13 UJ	---- -	---- -
SEM Cadmium	0.04 J	---- -	---- -	---- -	---- -	0.03 J
Calcium Total	---- -	2110 J	---- -	2140 J	---- -	---- -
SEM Calcium	224	---- -	---- -	---- -	---- -	286
Chromium Total	---- -	10.6 J	---- -	4.7 J	---- -	---- -
SEM Chromium	0.02 U	---- -	---- -	---- -	---- -	0.02 U
Cobalt Total	---- -	7.7 J	---- -	4.6 J	---- -	---- -
SEM Cobalt	0.05 J	---- -	---- -	---- -	---- -	0.09 J
Copper Total	---- -	9.5 J	---- -	4.9 J	---- -	---- -
SEM Copper	1.9	---- -	---- -	---- -	---- -	0.8
Iron Total	---- -	14800 J	---- -	10600 J	---- -	---- -
SEM Iron	124	---- -	---- -	---- -	---- -	108
Lead Total	---- -	9.9 J	---- -	8.2 J	---- -	---- -
SEM Lead	0.81	---- -	---- -	---- -	---- -	0.77
Magnesium Total	---- -	2780 J	---- -	2510 J	---- -	---- -
SEM Magnesium	53.6	---- -	---- -	---- -	---- -	57.4
Manganese Total	---- -	794 J	---- -	820 J	---- -	---- -

Analytical Results for URS Background Non-Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKNON-01 61020 10/03/00 0.16 - 0.66	SSBKNON-02 61021 10/03/00 0.16 - 0.66	SSBKNON-03 61022 10/03/00 0.16 - 0.66	SSBKNON-04 61023 10/03/00 0.16 - 0.66	SSBKNON-05 61024 10/04/00 0.16 - 0.66	SSBKNON-06 61025 10/04/00 0.16 - 0.66
Metals, mg/kg						
SEM Manganese	13.8	---- -	---- -	---- -	---- -	20.4
SEM Mercury	---- R	---- -	---- -	---- -	---- -	---- R
Molybdenum Total	---- -	0.29 UJ	---- -	0.23 UJ	---- -	---- -
SEM Molybdenum	0.03 J	---- -	---- -	---- -	---- -	0.04 J
Nickel Total	---- -	10.3 J	---- -	5.5 J	---- -	---- -
SEM Nickel	0.6 J	---- -	---- -	---- -	---- -	0.36 J
Potassium Total	---- -	2370 J	---- -	2390 J	---- -	---- -
SEM Potassium	189	---- -	---- -	---- -	---- -	118
Selenium Total	---- -	0.36 UJ	---- -	0.37 UJ	---- -	---- -
SEM Selenium	0.05 J	---- -	---- -	---- -	---- -	0.05 U
Silver Total	---- -	0.14 UJ	---- -	0.15 UJ	---- -	---- -
SEM Silver	0.02 U	---- -	---- -	---- -	---- -	0.02 U
Sodium Total	---- -	82.4 J	---- -	62.7 J	---- -	---- -
SEM Sodium	4.9 U	---- -	---- -	---- -	---- -	5.5 U
Thallium Total	---- -	0.14 J	---- -	0.16 J	---- -	---- -
SEM Thallium	0.11 U	---- -	---- -	---- -	---- -	0.12 U
SEM Uranium	0.41	---- -	---- -	---- -	---- -	1.2
Uranium, Calculated Total	---- -	3.65	---- -	4.32	---- -	---- -
Vanadium Total	---- -	25.3 J	---- -	15.5 J	---- -	---- -
SEM Vanadium	0.19 J	---- -	---- -	---- -	---- -	0.16 J
Zinc Total	---- -	39.3 J	---- -	36.3 J	---- -	---- -
SEM Zinc	1.4	---- -	---- -	---- -	---- -	1.5
Other Parameters						
Cation Exchange Capacity, meq/g	0.16	---- -	---- -	---- -	---- -	0.134
Moisture Content, %	4.53	6.29	5.42	7.34	8.85	4.87
pH, SU	6.13	6.5	6.33	6.6	6.24	6.05
Total Organic Carbon, mg/kg	22750	13850	18550	24900	21550	20950
Radionuclides, pCi/g						
Lead 210 Total	---- -	2.6 +/- 1.5 UJ	---- -	3.6 +/- 1.3 UJ	---- -	---- -
Polonium 210 Total	---- -	-1.932 +/- 3.749 UJ	---- -	-1.202 +/- 3.498 UJ	---- -	---- -
Radium 226, Calculated Total	---- -	1.4 +/- 0.089	---- -	2.3 +/- 0.14	---- -	---- -
Radium 228 Total	---- -	1.64 +/- 0.11	---- -	2.97 +/- 0.19	---- -	---- -
Thorium 227 Total	---- -	0.192 +/- 0.12	---- -	0.131 +/- 0.095	---- -	---- -
Thorium 228 Total	---- -	1.62 +/- 0.26	---- -	3.1 +/- 0.36	---- -	---- -

Analytical Results for URS Background Non-Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: Sample ID: Sample Date: Sample Depth (ft.): **Parameter**	SSBKNON-01 61020 10/03/00 0.16 - 0.66	SSBKNON-02 61021 10/03/00 0.16 - 0.66	SSBKNON-03 61022 10/03/00 0.16 - 0.66	SSBKNON-04 61023 10/03/00 0.16 - 0.66	SSBKNON-05 61024 10/04/00 0.16 - 0.66	SSBKNON-06 61025 10/04/00 0.16 - 0.66
Radionuclides, pCi/g						
Thorium 230 Total	---- -	0.987 +/- 0.18	---- -	1.76 +/- 0.25	---- -	---- -
Thorium 232 Total	---- -	1.59 +/- 0.24	---- -	3.1 +/- 0.35	---- -	---- -
Uranium 234 Total	---- -	1.16 +/- 0.22	---- -	1.46 +/- 0.25	---- -	---- -
Uranium 235 Total	---- -	0.101 +/- 0.067	---- -	0.0493 +/- 0.048 U	---- -	---- -
Uranium 238 Total	---- -	1.21 +/- 0.22	---- -	1.45 +/- 0.25	---- -	---- -

Analytical Results for URS Background Non-Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKNON-07 61026 10/09/00 0.16 - 0.66	SSBKNON-08 61027 10/09/00 0.16 - 0.66	SSBKNON-09 61028 10/09/00 0.16 - 0.66	SSBKNON-10 61029 10/09/00 0.16 - 0.66	SSBKNON-11 61030 10/09/00 0.16 - 0.66	SSBKNON-12 61031 10/10/00 0.16 - 0.66
Inorganics, mg/kg						
SEM Phosphorus	---- -	---- -	---- -	---- -	9 J	---- -
Metals, meq/100g						
EM Calcium	---- -	---- -	---- -	---- -	5.83	---- -
EM Magnesium	---- -	---- -	---- -	---- -	1.26	---- -
EM Potassium	---- -	---- -	---- -	---- -	0.198	---- -
EM Sodium	---- -	---- -	---- -	---- -	0.081	---- -
Metals, mg/kg						
Aluminum Total	12200 J	---- -	13000 J	---- -	---- -	8270 J
SEM Aluminum	---- -	---- -	---- -	---- -	0.17 U	---- -
Antimony Total	0.93 J	---- -	0.99 J	---- -	---- -	0.69 J
SEM Antimony	---- -	---- -	---- -	---- -	0.11 U	---- -
Arsenic Total	2.5 J	---- -	1.5 J	---- -	---- -	1.3 J
SEM Arsenic	---- -	---- -	---- -	---- -	0.09 U	---- -
Barium Total	150 J	---- -	246 J	---- -	---- -	161 J
SEM Barium	---- -	---- -	---- -	---- -	2 J	---- -
Beryllium Total	1.4 J	---- -	0.84 J	---- -	---- -	0.36 J
SEM Beryllium	---- -	---- -	---- -	---- -	0.002 J	---- -
Cadmium Total	0.11 UJ	---- -	0.14 UJ	---- -	---- -	0.11 UJ
SEM Cadmium	---- -	---- -	---- -	---- -	0.02 J	---- -
Calcium Total	3390 J	---- -	2960 J	---- -	---- -	1660 J
SEM Calcium	---- -	---- -	---- -	---- -	220	---- -
Chromium Total	8.6 J	---- -	6.5 J	---- -	---- -	6.2 J
SEM Chromium	---- -	---- -	---- -	---- -	0.03 J	---- -
Cobalt Total	5.3 J	---- -	4.5 J	---- -	---- -	5.1 J
SEM Cobalt	---- -	---- -	---- -	---- -	0.12 J	---- -
Copper Total	14.7 J	---- -	12.2 J	---- -	---- -	6.2 J
SEM Copper	---- -	---- -	---- -	---- -	3.2	---- -
Iron Total	14000 J	---- -	12200 J	---- -	---- -	9800 J
SEM Iron	---- -	---- -	---- -	---- -	127	---- -
Lead Total	12.3 J	---- -	10.5 J	---- -	---- -	9 J
SEM Lead	---- -	---- -	---- -	---- -	0.99	---- -
Magnesium Total	2770 J	---- -	2440 J	---- -	---- -	2200 J
SEM Magnesium	---- -	---- -	---- -	---- -	90.6	---- -
Manganese Total	588 J	---- -	802 J	---- -	---- -	727 J

Analytical Results for URS Background Non-Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKNON-07 61026 10/09/00 0.16 - 0.66	SSBKNON-08 61027 10/09/00 0.16 - 0.66	SSBKNON-09 61028 10/09/00 0.16 - 0.66	SSBKNON-10 61029 10/09/00 0.16 - 0.66	SSBKNON-11 61030 10/09/00 0.16 - 0.66	SSBKNON-12 61031 10/10/00 0.16 - 0.66
Metals, mg/kg						
SEM Manganese	---- -	---- -	---- -	---- -	23.2	---- -
SEM Mercury	---- -	---- -	---- -	---- -	---- R	---- -
Molybdenum Total	0.36 UJ	---- -	0.49 UJ	---- -	---- -	0.33 UJ
SEM Molybdenum	---- -	---- -	---- -	---- -	0.03 J	---- -
Nickel Total	8.6 J	---- -	7 J	---- -	---- -	6.3 J
SEM Nickel	---- -	---- -	---- -	---- -	0.4 J	---- -
Potassium Total	2040 J	---- -	2010 J	---- -	---- -	1760 J
SEM Potassium	---- -	---- -	---- -	---- -	71.7	---- -
Selenium Total	0.41 UJ	---- -	0.41 UJ	---- -	---- -	0.36 UJ
SEM Selenium	---- -	---- -	---- -	---- -	0.07 J	---- -
Silver Total	0.16 UJ	---- -	0.16 UJ	---- -	---- -	0.14 UJ
SEM Silver	---- -	---- -	---- -	---- -	0.02 U	---- -
Sodium Total	112 J	---- -	133 J	---- -	---- -	73 J
SEM Sodium	---- -	---- -	---- -	---- -	17.2	---- -
Thallium Total	0.1 J	---- -	0.12 J	---- -	---- -	0.15 J
SEM Thallium	---- -	---- -	---- -	---- -	0.12 U	---- -
SEM Uranium	---- -	---- -	---- -	---- -	6.3	---- -
Uranium, Calculated Total	43.3	---- -	17.7	---- -	---- -	5.04
Vanadium Total	21.8 J	---- -	17.5 J	---- -	---- -	16.7 J
SEM Vanadium	---- -	---- -	---- -	---- -	0.26 J	---- -
Zinc Total	35.9 J	---- -	39.1 J	---- -	---- -	30.6 J
SEM Zinc	---- -	---- -	---- -	---- -	0.77	---- -
Other Parameters						
Cation Exchange Capacity, meq/g	---- -	---- -	---- -	---- -	0.0671	---- -
Moisture Content, %	13.35	12.73	10.63	5.45	5.29	5.83
pH, SU	6.35	5.9	6.25	5.55	6.23	6.52
Total Organic Carbon, mg/kg	41400	30000	27100	27650	8110	19300
Radionuclides, pCi/g						
Lead 210 Total	5.1 +/- 2.2 J	---- -	3.7 +/- 1.3 UJ	---- -	---- -	3 +/- 1.3 UJ
Polonium 210 Total	-2.647 +/- 5.365 UJ	---- -	-1.195 +/- 3.474 UJ	---- -	---- -	-1.311 +/- 3.269 UJ
Radium 226, Calculated Total	3.18 +/- 0.19	---- -	2.58 +/- 0.15	---- -	---- -	2.16 +/- 0.13
Radium 228 Total	2.94 +/- 0.18	---- -	2.5 +/- 0.15	---- -	---- -	2.31 +/- 0.15
Thorium 227 Total	0.242 +/- 0.12	---- -	0.146 +/- 0.11	---- -	---- -	0.219 +/- 0.11
Thorium 228 Total	2.93 +/- 0.33	---- -	1.95 +/- 0.27	---- -	---- -	1.89 +/- 0.25

Analytical Results for URS Background Non-Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: Sample ID: Sample Date: Sample Depth (ft.): **Parameter**	SSBKNON-07 61026 10/09/00 0.16 - 0.66	SSBKNON-08 61027 10/09/00 0.16 - 0.66	SSBKNON-09 61028 10/09/00 0.16 - 0.66	SSBKNON-10 61029 10/09/00 0.16 - 0.66	SSBKNON-11 61030 10/09/00 0.16 - 0.66	SSBKNON-12 61031 10/10/00 0.16 - 0.66
Radionuclides, pCi/g						
Thorium 230 Total	2.94 +/- 0.32	---- -	2.14 +/- 0.27	---- -	---- -	1.5 +/- 0.21
Thorium 232 Total	3.04 +/- 0.32	---- -	2.05 +/- 0.26	---- -	---- -	1.83 +/- 0.23
Uranium 234 Total	18.4 +/- 1.3	---- -	7.31 +/- 0.65	---- -	---- -	1.62 +/- 0.23
Uranium 235 Total	0.898 +/- 0.19	---- -	0.356 +/- 0.12	---- -	---- -	0.14 +/- 0.069
Uranium 238 Total	14.4 +/- 1.1	---- -	5.9 +/- 0.56	---- -	---- -	1.67 +/- 0.23

Analytical Results for URS Background Non-Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKNON-13 61032 10/10/00 0.16 - 0.66	SSBKNON-14 61033 10/10/00 0.16 - 0.66	SSBKNON-15 61034 10/10/00 0.16 - 0.66	SSBKNON-16 61035 10/10/00 0.16 - 0.66	SSBKNON-17 61036 10/11/00 0.16 - 0.66	SSBKNON-18 61037 10/11/00 0.16 - 0.66
Inorganics, mg/kg						
SEM Phosphorus	---- -	18.4 J	---- -	18.7 J	---- -	---- -
Metals, meq/100g						
EM Calcium	---- -	6.49	---- -	8.17	---- -	---- -
EM Magnesium	---- -	0.95	---- -	1.54	---- -	---- -
EM Potassium	---- -	0.436	---- -	0.778	---- -	---- -
EM Sodium	---- -	0.025	---- -	0.02	---- -	---- -
Metals, mg/kg						
Aluminum Total	---- -	---- -	10200 J	---- -	---- -	11600
SEM Aluminum	---- -	1.7 J	---- -	0.88 J	---- -	---- -
Antimony Total	---- -	---- -	0.82 J	---- -	---- -	0.89 UJ
SEM Antimony	---- -	0.11 U	---- -	0.11 U	---- -	---- -
Arsenic Total	---- -	---- -	0.88 J	---- -	---- -	1.8 J
SEM Arsenic	---- -	0.09 U	---- -	0.07 U	---- -	---- -
Barium Total	---- -	---- -	172 J	---- -	---- -	176
SEM Barium	---- -	1.9 J	---- -	3.4 J	---- -	---- -
Beryllium Total	---- -	---- -	0.65 J	---- -	---- -	0.65
SEM Beryllium	---- -	0.002 J	---- -	0.002 U	---- -	---- -
Cadmium Total	---- -	---- -	0.15 UJ	---- -	---- -	0.06 UJ
SEM Cadmium	---- -	0.05 J	---- -	0.04 J	---- -	---- -
Calcium Total	---- -	---- -	2090 J	---- -	---- -	2380
SEM Calcium	---- -	199	---- -	276	---- -	---- -
Chromium Total	---- -	---- -	4.2 J	---- -	---- -	7 J
SEM Chromium	---- -	0.02 J	---- -	0.02 U	---- -	---- -
Cobalt Total	---- -	---- -	4.4 J	---- -	---- -	6.2
SEM Cobalt	---- -	0.06 J	---- -	0.08 J	---- -	---- -
Copper Total	---- -	---- -	6.4 J	---- -	---- -	8.1
SEM Copper	---- -	3.7	---- -	1.2	---- -	---- -
Iron Total	---- -	---- -	11500 J	---- -	---- -	12300
SEM Iron	---- -	168	---- -	98.5	---- -	---- -
Lead Total	---- -	---- -	9.2 J	---- -	---- -	9.3
SEM Lead	---- -	1.3	---- -	0.98	---- -	---- -
Magnesium Total	---- -	---- -	2700 J	---- -	---- -	2500
SEM Magnesium	---- -	62.1	---- -	75.2	---- -	---- -
Manganese Total	---- -	---- -	823 J	---- -	---- -	761

Analytical Results for URS Background Non-Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKNON-13 61032 10/10/00 0.16 - 0.66	SSBKNON-14 61033 10/10/00 0.16 - 0.66	SSBKNON-15 61034 10/10/00 0.16 - 0.66	SSBKNON-16 61035 10/10/00 0.16 - 0.66	SSBKNON-17 61036 10/11/00 0.16 - 0.66	SSBKNON-18 61037 10/11/00 0.16 - 0.66
Metals, mg/kg						
SEM Manganese	---- -	31.3	---- -	23	---- -	---- -
SEM Mercury	---- -	---- R	---- -	---- R	---- -	---- -
Molybdenum Total	---- -	---- -	0.54 J	---- -	---- -	0.27 J
SEM Molybdenum	---- -	0.04 J	---- -	0.02 U	---- -	---- -
Nickel Total	---- -	---- -	4.8 J	---- -	---- -	8.2
SEM Nickel	---- -	0.67 J	---- -	0.55 J	---- -	---- -
Potassium Total	---- -	---- -	2640 J	---- -	---- -	2170
SEM Potassium	---- -	209	---- -	247	---- -	---- -
Selenium Total	---- -	---- -	0.38 UJ	---- -	---- -	0.39 U
SEM Selenium	---- -	0.05 U	---- -	0.06 J	---- -	---- -
Silver Total	---- -	---- -	0.15 UJ	---- -	---- -	0.15 U
SEM Silver	---- -	0.02 U	---- -	0.02 U	---- -	---- -
Sodium Total	---- -	---- -	71.2 J	---- -	---- -	130
SEM Sodium	---- -	7.3 U	---- -	4.4 U	---- -	---- -
Thallium Total	---- -	---- -	0.17 J	---- -	---- -	0.15 J
SEM Thallium	---- -	0.11 U	---- -	0.12 U	---- -	---- -
SEM Uranium	---- -	0.62	---- -	0.33	---- -	---- -
Uranium, Calculated Total	---- -	---- -	7.15	---- -	---- -	3.63
Vanadium Total	---- -	---- -	16.5 J	---- -	---- -	20.1
SEM Vanadium	---- -	0.14 J	---- -	0.18 J	---- -	---- -
Zinc Total	---- -	---- -	44.9 J	---- -	---- -	38.5
SEM Zinc	---- -	2.2	---- -	0.85	---- -	---- -
Other Parameters						
Cation Exchange Capacity, meq/g	---- -	0.118	---- -	0.154	---- -	---- -
Moisture Content, %	7.97	4.52	4.72	5.73	7.56	7.06
pH, SU	6.5	6.42	6.7	6.65	6.66	6.45
Total Organic Carbon, mg/kg	24150	21100	24350	18400	24100	22200
Radionuclides, pCi/g						
Lead 210 Total	---- -	---- -	4.9 +/- 1.7 J	---- -	---- -	1.6 +/- 1.3 UJ
Polonium 210 Total	---- -	---- -	2.769 +/- 4.789 UJ	---- -	---- -	1.705 +/- 3.231 UJ
Radium 226, Calculated Total	---- -	---- -	3.07 +/- 0.18	---- -	---- -	1.61 +/- 0.098
Radium 228 Total	---- -	---- -	3.59 +/- 0.21	---- -	---- -	2.04 +/- 0.13
Thorium 227 Total	---- -	---- -	0.241 +/- 0.12	---- -	---- -	0.167 +/- 0.089
Thorium 228 Total	---- -	---- -	2.54 +/- 0.31	---- -	---- -	1.82 +/- 0.24

Analytical Results for URS Background Non-Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: Sample ID: Sample Date: Sample Depth (ft.): **Parameter**	SSBKNON-13 61032 10/10/00 0.16 - 0.66	SSBKNON-14 61033 10/10/00 0.16 - 0.66	SSBKNON-15 61034 10/10/00 0.16 - 0.66	SSBKNON-16 61035 10/10/00 0.16 - 0.66	SSBKNON-17 61036 10/11/00 0.16 - 0.66	SSBKNON-18 61037 10/11/00 0.16 - 0.66
Radionuclides, pCi/g						
Thorium 230 Total	---- -	---- -	2.33 +/- 0.28	---- -	---- -	1.39 +/- 0.19
Thorium 232 Total	---- -	---- -	2.49 +/- 0.29	---- -	---- -	1.82 +/- 0.22
Uranium 234 Total	---- -	---- -	2.23 +/- 0.29	---- -	---- -	1.02 +/- 0.16
Uranium 235 Total	---- -	---- -	0.133 +/- 0.071	---- -	---- -	0.0622 +/- 0.042
Uranium 238 Total	---- -	---- -	2.38 +/- 0.31	---- -	---- -	1.21 +/- 0.18

Analytical Results for URS Background Non-Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: / Sample ID: / Sample Date: / Sample Depth (ft.): / Parameter	SSBKNON-19 61038 10/11/00 0.16 - 0.66	SSBKNON-20 61039 10/11/00 0.16 - 0.66	----	----	----	----
Metals, mg/kg						
Aluminum Total	11300	---- -	---- -	---- -	---- -	---- -
Antimony Total	0.7 UJ	---- -	---- -	---- -	---- -	---- -
Arsenic Total	0.94 J	---- -	---- -	---- -	---- -	---- -
Barium Total	188	---- -	---- -	---- -	---- -	---- -
Beryllium Total	0.89	---- -	---- -	---- -	---- -	---- -
Cadmium Total	0.03 UJ	---- -	---- -	---- -	---- -	---- -
Calcium Total	1950	---- -	---- -	---- -	---- -	---- -
Chromium Total	2.8 J	---- -	---- -	---- -	---- -	---- -
Cobalt Total	3.8 J	---- -	---- -	---- -	---- -	---- -
Copper Total	6.9	---- -	---- -	---- -	---- -	---- -
Iron Total	9220	---- -	---- -	---- -	---- -	---- -
Lead Total	9.1	---- -	---- -	---- -	---- -	---- -
Magnesium Total	1970	---- -	---- -	---- -	---- -	---- -
Manganese Total	713	---- -	---- -	---- -	---- -	---- -
Molybdenum Total	0.47 J	---- -	---- -	---- -	---- -	---- -
Nickel Total	5.9	---- -	---- -	---- -	---- -	---- -
Potassium Total	2020	---- -	---- -	---- -	---- -	---- -
Selenium Total	0.42 U	---- -	---- -	---- -	---- -	---- -
Silver Total	0.16 U	---- -	---- -	---- -	---- -	---- -
Sodium Total	199	---- -	---- -	---- -	---- -	---- -
Thallium Total	0.13 J	---- -	---- -	---- -	---- -	---- -
Uranium, Calculated Total	7.53	---- -	---- -	---- -	---- -	---- -
Vanadium Total	12.9	---- -	---- -	---- -	---- -	---- -
Zinc Total	30.2	---- -	---- -	---- -	---- -	---- -
Other Parameters						
Moisture Content, %	6.16	4.42	---- -	---- -	---- -	---- -
pH, SU	6.22	6.46	---- -	---- -	---- -	---- -
Total Organic Carbon, mg/kg	23950	20600	---- -	---- -	---- -	---- -
Radionuclides, pCi/g						
Lead 210 Total	2.6 +/- 1. J	---- -	---- -	---- -	---- -	---- -
Polonium 210 Total	2.986 +/- 2.974 J	---- -	---- -	---- -	---- -	---- -
Radium 226, Calculated Total	2.89 +/- 0.17	---- -	---- -	---- -	---- -	---- -
Radium 228 Total	2.26 +/- 0.14	---- -	---- -	---- -	---- -	---- -
Thorium 227 Total	0.459 +/- 0.14	---- -	---- -	---- -	---- -	---- -

Analytical Results for URS Background Non-Mineralized Subsurface Material Samples

Midnite Mine RI/FS

Location ID: Sample ID: Sample Date: Sample Depth (ft.): **Parameter**	**SSBKNON-19** **61038** **10/11/00** **0.16 - 0.66**	**SSBKNON-20** **61039** **10/11/00** **0.16 - 0.66**	**----**	**----**	**----**	**----**
Radionuclides, pCi/g						
Thorium 228 Total	2.45 +/- 0.27	---- -	---- -	---- -	---- -	---- -
Thorium 230 Total	2.33 +/- 0.24	---- -	---- -	---- -	---- -	---- -
Thorium 232 Total	2.26 +/- 0.24	---- -	---- -	---- -	---- -	---- -
Uranium 234 Total	2.71 +/- 0.3	---- -	---- -	---- -	---- -	---- -
Uranium 235 Total	0.176 +/- 0.073	---- -	---- -	---- -	---- -	---- -
Uranium 238 Total	2.5 +/- 0.28	---- -	---- -	---- -	---- -	---- -

Attachment D

Source: Supporting Documentation to the Midnite Mine RI Report (URS 2005).

In Attachment D, there are two Radium 226 results provided for each sample in the Excel Spreadsheet: "Radium 226" and "Radium 226, Calculated Total." The data values associated with the analyte labelled "Radium 226, Calculated Total" are the values that were used to calculate background cleanup levels at the Site. These data values are Radium 226 total concentrations and they were not "calculated." It is possible that the term "calculated" was a carryover from earlier data which were analyzed by the radon emanation method (which does "calculate" Ra-226).

In the gamma spectrometry method, the peak that is measured for Ra-226 concentrations also includes U-235 concentrations. In the Excel Spreadsheet in Attachment D, concentrations from this combined peak are listed for the analyte "Radium 226." These concentrations were not used to calculate background concentrations because this combined peak overestimates Ra-226 concentrations. Because of this combined peak, in the gamma spectrometry method a different peak (Bismuth 214) on the graph is measured to obtain the Ra-226 concentrations – in a sample, the Bismuth 214 peak will always have the same concentration as Ra-226 because both radionuclides will have reached secular equilibrium at 21 days. In the spreadsheet, this can be confirmed by comparing the "Radium 226, Calculated" and "Bismuth 214" concentrations and they are the same value.

Native xls is provided separately.

Attachment E

ProUCL Background Statistics to Confirm Ra-226 Cleanup Level

Prepared by Aditya Tyagi, CH2M HILL (EPA Contractor)

Analyte	Value
Radium 226	1.89
Radium 226	2.2
Radium 226	1.97
Radium 226	2.11
Radium 226	1.66
Radium 226	1.56
Radium 226	3
Radium 226	3.87
Radium 226	1.4
Radium 226	2.3
Radium 226	3.18
Radium 226	2.58
Radium 226	2.16
Radium 226	3.07
Radium 226	1.61
Radium 226	2.89

Background Areas A and B
Surface Material
Subsurface Data
Summarized from Table 1 of this memorandum.

1				**Lognormal Background Statistics for Uncensored Full Data Sets**								
2			**User Selected Options**									
3			Date/Time of Computation	ProUCL 5.17/28/2017 9:58:33 AM								
4			From File	UTL for Radium Calculated_Soil Data.xls								
5			Full Precision	OFF								
6			Confidence Coefficient	95%								
7			Coverage	95%								
8			New or Future K Observations	1								
9			Number of Bootstrap Operations	2000								
10												
11	**Value**											
12												
13	**General Statistics**											
14						Total Number of Observations	16			Number of Distinct Observations	16	
15						Minimum	1.4			First Quartile	1.833	
16						Second Largest	3.18			Median	2.18	
17						Maximum	3.87			Third Quartile	2.918	
18						Mean	2.341			SD	0.698	
19						Coefficient of Variation	0.298			Skewness	0.638	
20						Mean of logged Data	0.81			SD of logged Data	0.294	
21												
22						**Critical Values for Background Threshold Values (BTVs)**							
23						Tolerance Factor K (For UTL)	2.524			d2max (for USL)	2.443	
24												
25						**Lognormal GOF Test**						
26						Shapiro Wilk Test Statistic	0.97			**Shapiro Wilk Lognormal GOF Test**		
27						5% Shapiro Wilk Critical Value	0.887			Data appear Lognormal at 5% Significance Level		
28						Lilliefors Test Statistic	0.117			**Lilliefors Lognormal GOF Test**		
29						5% Lilliefors Critical Value	0.213			Data appear Lognormal at 5% Significance Level		
30						**Data appear Lognormal at 5% Significance Level**						
31												
32						**Background Statistics assuming Lognormal Distribution**						
33						95% UTL with 95% Coverage	4.715			90% Percentile (z)	3.274	
34						95% UPL (t)	3.82			95% Percentile (z)	3.643	
35						95% USL	4.605			99% Percentile (z)	4.45	
36												
37	Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20.											
38	Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers											
39	and consists of observations collected from clean unimpacted locations.											
40	The use of USL tends to provide a balance between false positives and false negatives provided the data											
41	represents a background data set and when many onsite observations need to be compared with the BTV.											
42												

Attachment 2

Table 4-12
Background Limits and Retest Background Limits
Summary Statistics for Surface Material and Soils

Draft (12/12/01) Statistical Analysis of Midnite Mine Background Surface Materials (SM) Data (SB and SS)									
Matrix Type	Parameter	N	ND	Report Min	Report Max	Distribution	BL	RBL	Units
SS	Aluminum	40	0	8230	24100	NP	24,100	24,100	mg/kg
SS	Arsenic	40	4	0.1804	234	NP	234	234	mg/kg
SS	Cadmium	40	0	0.09	0.45	NO	0.44	0.47	mg/kg
SS	Chromium	40	0	3.6	18.2	NO	17.90	19.20	mg/kg
SS	Copper	40	0	4.6	41.8	NP	41.80	42	mg/kg
SS	Lead	40	0	7.4	20.9	LN	20.25	21.76	mg/kg
SS	$Lead^{210}$	40	0	1.1	11	LN	7.48	8.56	pCi/g
SS	Manganese	40	0	254	1640	NO	1445	1534	mg/kg
SS	$Radium^{226}$ Calculated	40	0	1.33	8.92	NP	8.92	8.92	pCi/g
SS	Selenium	40	37	0.0433	0.52	NP	0.52	0.52	mg/kg
SS	$Uranium^{238}$	40	0	0.779	15.2	NP	15.2	15.20	pCi/g
SS	Zinc	40	0	17.2	62.4	NO	65	68.03	mg/kg
SB	Aluminum	16	0	7720	16500	NO	18,453	18,830	mg/kg
SB	Arsenic	16	0	0.78	86.1	NP	86	86	mg/kg
SB	Cadmium	16	16	0.03	0.32	NP	0.32	0.32	mg/kg
SB	Chromium	16	0	2.8	14.9	LN	21.32	22.85	mg/kg
SB	Copper	16	0	4.9	35.8	LN	56.07	61	mg/kg
SB	Lead	16	0	8.2	12.3	LN	12.80	13.01	mg/kg
SB	$Lead^{210}$	16	0	1.2	5.1	LN	7.68	8.21	pCi/g
SB	Manganese	16	0	379	1300	LN	1447	1509	mg/kg
SB	$Radium^{226}$ ~~Calculated~~	16	0	1.4	3.87	LN	4.72	~~4.94~~	~~pCi/g~~
SB	Selenium	16	13	0.2222	0.56	NP	0.56	0.56	mg/kg
SB	$Uranium^{238}$	16	0	0.834	14.4	NP	14.40	14.40	pCi/g
SB	Zinc	16	0	26.6	44.9	NO	50.58	51	mg/kg

This value is a 95% UTL.

Draft (12/12/01) Statistical Analysis of Midnite Mine Background Sediment (SED) Data (CS and ES)									
Matrix Type	Parameter	N	ND	Report Min	Report Max	Distribution	BL	RBL	Units
ES	Cadmium	22	2	<0.02	0.69	LN	1.01	1.23	mg/kg
ES	Chromium	22	0	1.1	23.1	NO	27.58	29.11	mg/kg
ES	Cobalt	22	0	0.92	13.9	LN	28.57	33.27	mg/kg
ES	Lead	22	0	2.9	20.2	NO	20.72	21.65	mg/kg
ES	Manganese	22	0	97.9	1420	LN	1,704	1976	mg/kg
ES	Nickel	22	0	0.72	25.6	NO	26.60	28.17	mg/kg
ES	$Polonium^{210}$	22	0	0.6	10	LN	17.93	21.39	pCi/g
ES	$Radium^{226}$	22	0	0.952	8.47	LN	20.58	23.39	pCi/g
ES	Sulfate	22	0	0.656	185	LN	333	476	mg/kg
ES	$Uranium^{238}$	22	0	0.975		LN	55.99	71	pCi/g
CS	Cadmium	22	3	<0.02	0.68	LN	1.02	1.24	mg/kg
CS	Chromium	22	0	1.4	22.3	NO	23.22	24.39	mg/kg
CS	Cobalt	22	0	0.91	12.9	NO	14.49	15.21	mg/kg
CS	Lead	22	0	4	21	LN	24.80	26.98	mg/kg
CS	Manganese	22	0	88.6	871	LN	1178	1,323	mg/kg
CS	Nickel	22	0	0.89	23.8	NO	23.45	24.76	mg/kg
CS	$Polonium^{210}$	22	0	0.7	18	LN	17.44	20.81	pCi/g
CS	$Radium^{226}$	22	0	1.36	8.21	LN	13.05	14.56	pCi/g
CS	Sulfate	22	0	1.08	168	LN	290.05	403	mg/kg
CS	$Uranium^{238}$	22	0	0.79	22	LN	31.05	38.32	pCi/g

Notes:

N	Number of samples	ES	Grab Sample
ND	Number of non-detects	<	Less than report minimum
BL	Background Limit (99% upper tolerance limit)	mg/kg	Milligrams per kilogram
RBL	Retest Background Limit (95% upper prediction limit)	pCi/g	PicoCuries per gram
SB	5-20 centimeter sample interval	NP	Non-Parametric
SS	0-5 centimeter sample interval	NO	Normal
CS	Composite Sample	LN	Lognormal

Table 5-3. Background Limits and Retest Background Limits Summary Statistics for Surface Material and Sediment

From May 2002 (Draft) Technical Memorandum, Background Statistics for Midnite Mine RI/FS

Matrix Type	Parameter	N[c]	ND[d]	Report Minimum[e]	Report Maximum	Distribution	Background Limit[f]	Retest Background Limit[g]	Units	HHRA[h] 95% UTL[i]	Units
SS	Aluminum	40	0	8,200	24,000	NP[j]	24,000	24,000	mg/kg[k]	18,000	mg/kg
SS	Arsenic	40	4	0.18	230	NP	230	230	mg/kg	86	mg/kg
SS	Cadmium	40	0	0.090	0.45	NO[l]	0.44	0.47	mg/kg	0.32	mg/kg
SS	Chromium	40	0	3.6	18	NO	18	19	mg/kg	18	mg/kg
SS	Copper	40	0	4.6	42	NP	42	42	mg/kg	42	mg/kg
SS	Lead	40	0	7.4	21	LN[m]	20	22	mg/kg	13	mg/kg
SS	Lead-210	40	0	1.1	11	LN	7.5	8.6	pCi/g[n]	7.7	pCi/g
SS	Manganese	40	0	250	1,600	NO	1,400	1,500	mg/kg	1,400	mg/kg
SS	Radium-226 Calculated	40	0	1.3	8.9	NP	8.9	8.9	pCi/g	4.7	pCi/g
SS	Selenium	40	37	0.043	0.52	NP	0.52	0.52	mg/kg	0.52	mg/kg
SS	Uranium-238	40	0	0.78	15	NP	15	15	pCi/g	43	mg/kg
SS	Zinc	40	0	17	62	NO	65	68	mg/kg	51	mg/kg
SB	Aluminum	16	0	7,700	17,000	NO	18,000	19,000	mg/kg	17,000	mg/kg
SB	Arsenic	16	0	0.78	86	NP	86	86	mg/kg	86	mg/kg
SB	Cadmium	16	16	0.030	0.32	NP	0.32	0.32	mg/kg	0.32	mg/kg
SB	Chromium	16	0	2.8	15	LN	21	23	mg/kg	16	mg/kg
SB	Copper	16	0	4.9	36	LN	56	61	mg/kg	36	mg/kg
SB	Lead	16	0	8.2	12	LN	13	13	mg/kg	12	mg/kg
SB	Lead-210	16	0	1.2	5.1	LN	7.7	8.2	pCi/g	5.7	pCi/g
SB	Manganese	16	0	380	1,300	LN	1,400	1,500	mg/kg	1,200	mg/kg
SB	Radium-226 Calculated	16	0	1.4	3.9	LN	4.7	4.9	pCi/g	3.8	pCi/g
SB	Selenium	16	13	0.22	0.56	NP	0.56	0.56	mg/kg	0.11	mg/kg
SB	Uranium-238	16	0	0.83	14	NP	14	14	pCi/g	43	mg/kg
SB	Zinc	16	0	27	45	NO	51	51	mg/kg	46	mg/kg

(Table Continues)

This value is 95% UTL